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Quality of Subjective Experience and Psychophysiology: Implications for Optimal Human Functioning

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Quality of Subjective Experience and Psychophysiology: Implications for Optimal Human Functioning

Tese de Doutoramento em Psicologia
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Trabalho efetuado sob a orientação da
Professora Doutora Teresa Freire
e da
Professora Doutora Nancy A. Nicolson

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"*There is no such thing as a 'self-made' man. We are made up of thousands of others. Everyone who has ever done a kind deed for us, or spoken one word of encouragement to us, has entered into the make-up of our character and our thoughts, as well as our success*."

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"*If you want to tell people the truth,*
make them laugh, otherwise they'll kill you."
-- Oscar Wilde

To *Mara* and *Norberto*

ABSTRACT

Theoretical background: The flow state, characterized by intense engagement, high levels of concentration, intrinsic motivation, and enjoyment, seems to influence personal and societal development. Furthermore, some individuals (autotelic personality) have a greater propensity to experience engagement in daily life, which translates into a better mental and physical functioning. Although there has been extensive research about the flow state and the autotelic personality for the past decades, there is still little known about their physiological correlates in daily life.

Aims: The main aims of this research project were to investigate the associations between momentary experiences of engagement (flow) and subjective experiences in the daily contexts of female college students – study and solitude –, and investigate whether the autotelic personality and affectivity were associated with subjective experience and neuroendocrine response to daily contexts and cortisol secretion.

Method: Sixty-seven female college students from the University of Minho, Portugal, used the Experience Sampling Method during a week, completing questionnaires and collecting saliva 8 times daily. Effects of current daily contexts (solitude and study activity), engagement, and personal characteristics (autotelic personality and affectivity) on subjective experience and cortisol secretion were tested.

Results: Engagement levels were associated with better subjective experience in daily contexts, but not with cortisol. Daily solitude was associated with heightened affective and neuroendocrine responses, especially in students with high negative affectivity. High autotelic traits and positive affectivity were associated with better affective experiences in solitude and greater motivation and engagement levels in study activities; high negative affectivity showed the opposite pattern. Finally, autotelic personality was not associated with other measures of cortisol secretion.

Conclusions: Current findings offered new clues about the assessment of the psychophysiology of flow and autotelic personality. Findings may help clarify how daily contexts heighten affective and neuroendocrine response in individuals vulnerable to depression and other negative health outcomes. Current research leads to questions about possible gender differences in neuroendocrine responses to flow in

daily life and offers future directions in the study of the physiological functioning of engagement and the autotelic personality.

RESUMO

Enquadramento teórico: O estado de *Flow*, caracterizado por um envolvimento intenso, elevados níveis de concentração, motivação intrínseca, e prazer, parece ter influência sobre o desenvolvimento pessoal e social. Alguns indivíduos (*personalidade autotélica*) têm maior propensão para experienciar elevados níveis de envolvimento na vida diária, o que se traduz num melhor funcionamento físico e mental. Apesar da vasta investigação das últimas décadas acerca do estado de *flow* e da personalidade autotélica, ainda pouco se sabe acerca dos seus correlatos fisiológicos na vida diária.

Objetivos: Assim, os principais objectivos deste projecto de investigação eram investigar as associações entre a experiência diária de elevado envolvimento (*flow*) e a experiência subjetiva nos contextos diários das estudantes universitárias – atividades de estudo e estar só – , e investigar se a personalidade autotélica e a afetividade estariam associadas com a experiência subjetiva, a resposta neuroendócrina aos contextos diários, e a secreção de cortisol.

Método: Sessenta e sete estudantes universitárias da Universidade do Minho, Portugal, utilizaram o *Experience Sampling Method* durante uma semana, preenchendo questionários e colhendo amostras de saliva oito vezes por dia. Testámos os efeitos dos contextos diários de vida (estar só e atividades de estudo), níveis de envolvimento, e características pessoais (personalidade autotélica e afetividade) na experiência subjectiva e na resposta e secreção de cortisol.

Resultados: Os níveis de envolvimento foram associados a uma melhor experiência subjetiva em contextos diários, mas não a níveis de cortisol. Estar só foi associado a uma maior resposta afetiva e neuroendócrina, especialmente em estudantes com elevada afetividade negativa. Elevadas personalidade autotélica e afetividade positiva foram associadas a experiências afetivas mais positivas quando os estudantes estavam sós, e a maior motivação e envolvimento em atividades de estudo; a afetividade negativa demonstrou o padrão oposto. Finalmente, a personalidade autotélica não estava associada a outras medidas relativas à secreção de cortisol.

Conclusões: Os resultados oferecem novas pistas acerca da avaliação da psicofisiologia do estado de *flow* e da personalidade autotélica. Os resultados podem

ajudar a clarificar como os contextos diários aumentam a resposta afetiva e neuroendócrina em indivíduos vulneráveis ao desenvolvimento de depressão e outras consequências negativas de saúde. Finalmente, esta investigação resultou na emergência de novas questões acerca de possíveis diferenças de género na resposta neuroendócrina à experiência de *flow* na vida diária, e oferece futuras direcções para o estudo do funcionamento fisiológico em experiências de elevado envolvimento e em indivíduos com personalidade autotélica.

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Abbreviations List

ESM	Experience sampling method
EFM	Experience fluctuation model
ESF	Experience sampling form
ANS	Autonomic nervous system
HPA	Hypothalamic-pituitary-adrenocortical
PFC	Pre-frontal cortex
CRH	Corticotropin releasing hormone
POMC	Pituitary opiomelanocortin
ACTH	Adrenocorticotropic hormone
MR	Mineralocorticoid receptor
GR	Glucocorticoid receptor
CAR	Cortisol awakening response
PA	Positive affect
NA	Negative affect
BL	Balance levels of experience
AL	Autotelicity levels of experience
EL	Engagement levels of experience
AP	Autotelic personality
meanPA	Positive affectivity
meanNA	Negative affectivity
vPA	Variations in momentary PA
vNA	Variations in momentary NA

Introduction

Introduction

What is a good life and how do we achieve it? What are the individual processes, experiences, and contexts that promote optimal mental and physical functioning? Philosophers, sociologists, and psychologists have posed these questions through human history. Positive psychology, officially introduced in the year 2000 in the special issue of the journal American Psychologist, has set itself to answer these and other questions related to optimal human functioning and flourishing. The aim of positive psychology is to study the components of psychological function and contexts that promote human development. It can complement other fields of psychology in the study of positive human development. Positive psychology draws influences from the humanistic movement and proposes the creation of a strong empirical research field to study human strengths and virtues, growth and experiences and contexts that promote a *good life* (Seligman, 2002; Seligman & Csikszentmihalyi, 2000). Although the study of well-being, positive coping, and the flow state, among others, was not new, the organization of constructs within a unified field created a greater impetus for the development of new methods to assess human strengths and qualities. But positive psychology doesn't focus solely on positive states and traits. Positive psychology is concerned with the interactions between the individual and context, and how these interactions contribute to positive function even in negative conditions. Moreover, positive psychology is concerned with how positive conditions can precede negative function (Nakamura, 2011). For example, parental support that is not accompanied by an adequate amount of demand and responsibility can lead to the lack coping resources needed to face stressful contexts in daily life. In turn, the lack of coping resources can have important implications in the sense of self-competency and increase vulnerability to stress. Therefore, our aim is to understand "*how the various contexts of daily life can be shaped so that they are resources for, rather than obstacles to flourishing*" (Nakamura, 2011). This is only achieved with the integration of what is positive and negative, and the understanding of the role of the self and the surrounding context, within the framework of positive social science.

The current study allies positive social psychology and psychophysiology in the study of the role of individual characteristics and environmental opportunities in daily

experience and physiological function. The person-environment interaction is responsible for psychological development, physiological function, and even gene expression (Rutter, 2010). The study of physiological correlates of positive states and traits has proven valuable to understand the conditions that prevent pathophysiology, increase resilience, and contribute to better health and greater longevity. Research has established that positive characteristics (e.g., happiness, social support, self-esteem, optimism) and contexts (e.g., social interactions, leisure activities) are associated with healthier lifestyles, enhanced physiological function and greater longevity (Bunting, Tolson, Kuhn, Suarez, & Williams, 2000; Chida & Steptoe, 2008; Danner, Snowdon, & Friesen, 2001; Diener & Biswas-Diener, 2008; Etnier, 2008; Hansen, Blangsted, Hansen, Sogaard, & Sjogaard, 2010; Harte, Eifert, & Smith, 1995; Howell, 2009; Pressman & Cohen, 2007; Pressman, et al., 2009; M. Seeman & Lewis, 1995; Taylor, 2011; Taylor, Lerner, Sherman, Sage, & McDowell, 2003). In the current research, we focus on the flow state, an experience of intense engagement and enjoyment associated with beneficial psychological and physiological effects. The flow state is a key experience in the development of personal and professional trajectories and in the creation, reproduction and transformation of cultural information.

In the first part (*Theoretical Background*), we describe the flow model and its associations with psychological, contextual, and physiological functioning. In the first chapter (*The Flow experience, the autotelic personality and daily experience and contexts*), we explore the role of engagement and interest in personal and cultural development, within the framework of psychological selection. Furthermore, we explore the associations of the flow state with state and trait psychological characteristics. We discuss the strengths and limitations of the methods most often used to assess flow in daily life. In the second chapter (*Flow and Psychophysiology in Daily Life*), we review research conducted about the associations between neuroendocrine function, the flow state, everyday experience, and personality characteristics.

In the second part (*Empirical Research*), we describe the characteristics of this all-female college student sample, as well as the instruments, procedure, and variables used in the current research project in the third chapter (*Method*). In the fourth chapter (*The flow experience: everyday experience and physiological function*), we explored

the associations between the flow state, or engagement, momentary psycho-affective experience, and neuroendocrine activation. We investigated the associations between experiencing high engagement in daily life, momentary subjective experience, and cortisol in distinct daily contexts. In the fifth chapter (*Personal characteristics, everyday experience and cortisol*), we investigated whether personal characteristics (autotelic personality, positive affectivity, and negative affectivity) were associated with differences in momentary subjective experience, engagement, and cortisol.

Finally, the last part (*Conclusions*) summarizes and integrates the main findings, highlights the implications of these findings for research and intervention, and advances new questions for future research in the field of positive social psychophysiology.

Part I: Theoretical Background

Chapter 1: The Flow experience, the autotelic personality and daily experience and contexts

"Through learning we grow, becoming more than we were before, and in that sense learning is unselfish, because it results in the transformation of what we were before, a setting aside of the old self in favor of a more complex one."

Mihalyi Csikszentmihalyi

Evolutionary needs lead to the development of several advantageous characteristics and abilities - from opposable thumbs to the development of complex language - that helped humans thrive in their natural environment. Perhaps one of the most important of these was the development of a conscious self (Csikszentmihalyi, 1993; Csikszentmihalyi & Csikszentmihalyi, 1988). The self contains information about the physical body and the mental, emotional, and historical characteristics of the individual. It is not a static structure: it adapts according to the information it receives from the physical and cultural environment. It is responsible for free will: it is an autonomous, deliberative structure capable of creative thinking, weighing options, reflecting over problems, and developing solutions to surpass physical problems or cultural establishments (Bandura, 2001; Baumeister, 2008; Csikszentmihalyi, 1993, 1997a, 2002; Csikszentmihalyi & Csikszentmihalyi, 1988). The self acts as a mediator between genetic instructions and cultural norms, choosing freely between them. The self directs attention toward self-determined goals and helps develop personal and professional trajectories as a result of the interaction with its environment (Csikszentmihalyi, 1997a, 2002; Csikszentmihalyi & Csikszentmihalyi, 1988; Delle Fave, Massimini, & Bassi, 2011; Massimini, Csikszentmihalyi, & Delle Fave, 1988; Massimini & Delle Fave, 2000).

The *psychological selection theory* (Delle Fave, et al., 2011; Massimini & Delle Fave, 2000) emerges from the view of the individual as an autonomous being, active in its own personal development. Since attention is a limited resource, it must be invested in things that are important to the self; these might be related to the achievement of goals associated with genetic instructions, cultural norms, and new developments of the social and physical environments. According to the psychological selection theory, individuals select information from their environments, develop *life themes*, and attend

to information that is relevant to the attainment of these goals. The aim of genes and cultural information (*memes*) is to be transmitted and replicated, like the self. The psychological selection theory proposes that certain experiences are transmitted to the detriment of others. This selection arises from historical needs, such as dominance of one culture over another, or, at the individual level, by intense emotional experiences. Regardless of the great impact of fortuitous situations on the human *psyche*, the development and adaptation of individual's personal and professional trajectories is mainly construed in relation to daily life contexts and interactions. For example, many creative individuals who come from harsh environments often flourish as a result of having a mentor in their lives, who supports their skills and offers them the opportunity to explore their potential (Csikszentmihalyi, 1996). In particular, positive daily contexts and experiences foster positive adaptation and the development of positive traits through cumulative effects. For example, parents' practices that promote autonomy, challenges, and clarity of goals in young children are associated with the development of characteristics that promote engagement in everyday life; nurturing parents also promote secure attachment styles and higher self-esteem (DeHart, 2006; Inghilleri, 1999; Rathunde, 1996a, 2001; Rathunde & Csikszentmihalyi, 1991, 2005b). Flow, a state of intense engagement and enjoyment, is one of the main experiences that promote individual growth and development.

The flow state is a key experience in individual and cultural development. Flow plays a fundamental role in the psychological selection process (Delle Fave, et al., 2011; Massimini & Delle Fave, 2000). Key aspects of the flow state, such as curiosity and interest, are innate in humans. Interest and curiosity about the world around us and about how things work, allowed humans to surpass limitations of our genetic endowment and to control the environment around us. Positive affect, sense of strength and self-efficacy that follow a flow state are probably hard-wired to ensure the continuous pursuit of that experience. This leads to a continuous process that increases complexity in the individual's mental structures and physical abilities (Csikszentmihalyi, 1997a, 2002; Csikszentmihalyi & Csikszentmihalyi, 1988; Delle Fave, et al., 2011; Inghilleri, 1999; Massimini & Delle Fave, 2000). Over the short term, flow provides a positive psycho-affective experience and over the long run, flow stretches individual resources, increases complexity and promotes personal growth.

Furthermore, the experience of flow increases the sense of self-efficacy, enjoyment, and control over context (Bakker, 2005; Bassi, Steca, Delle Fave, & Caprara, 2007; Csikszentmihalyi, 2002; Kowal & Fortier, 1999; Nakamura & Csikszentmihalyi, 2002; Salanova, Bakker, & Llorens, 2006). This translates into an active approach not only to individual problems, but also to social and cultural issues: individual goals turn outwards to social and physical contexts, as personal beliefs of control over the self and the social and physical environments emerge (Bandura, 2001; Csikszentmihalyi & Beattie, 1979; Delle Fave, et al., 2011; Massimini & Delle Fave, 2000). Consequently, the individual contributes actively to the reproduction, transmission, extinction and creation of cultural information. Therefore, the individual - receptor, creator, and actor in each culture - transforms the social and physical context according to the experiences in everyday life.

The Flow State

Mihalyi Csikszentmihalyi conceptualized the flow state in the 1970's, as a result of his interest in the quality of intrinsically motivated experiences and the reasons why these experiences were different from other everyday experiences (Csikszentmihalyi & Csikszentmihalyi, 1988). The flow state emerges when there is harmony between goals, thoughts, and affect, which enables the full engagement of physical and mental resources. It is a state of *negentropia*, in which order enters consciousness and engagement can unfold. Regardless of the activity in which the flow state unfolds, the phenomenology of the experience is similar: the experience is perceived as autotelic, i.e., participants report that the activity is rewarding in itself; there is a complete focus of attention in the task, which is perceived as effortless; people loose awareness of their surroundings and perceive time as flowing differently; there is a sense of control over the performance in the activity; the individual loses the perception of conscious self, leaving no room for doubt, blame, or other intrusive thoughts. The end of the flow-inducing activity is followed by intense feelings of strength, greater positive affect, increased sense of autonomy and competence, and desire to repeat the

experience (Csikszentmihalyi, 1996, 2002; Csikszentmihalyi & Lefevre, 1989; Delle Fave & Massimini, 2005; Delle Fave, et al., 2011; Inghilleri, 1999; Kowal & Fortier, 1999; Nakamura & Csikszentmihalyi, 2002; Rogatko, 2009; Schernoff, Csikszentmihalyi, Schneider, & Schernoff, 2003; Wong & Csikszentmihalyi, 1991). Although the flow experience is perceived as effortless, it involves previous development of skills, deployment of effort through discipline, and habitual experience. Frequent training helps develop skill sets that allow individuals to tap into automatic processes and to flexibly call upon explicit processes without disrupting the experience of flow. Flow involves the development of skills and is frequently associated with high performance and great creative products in the most diverse fields and activities.

The flow state is experienced in a wide range of activities and most individuals identify it spontaneously, regardless of gender, age, or culture. However, certain characteristics of activities can promote its emergence: the presence of optimal challenges and opportunities for action and expression that match individual's skills; clear proximal goals and immediate and clear feedback - this increases the sense of control and helps one evaluate whether there is the need to adjust the course of action. Unsurprisingly, most flow experiences are associated with productive and leisure activities: these activities are usually highly structured, present gradual challenges, and aggregate most opportunities for flow.

However, even in structured activities, the flow state is fleeting, changing as internal resources and external opportunities change. The dynamic and chaotic nature of the flow state relies on the dynamic interchange between individual resources and contextual opportunities, which must be in constant balance. The need to balance internal resources and external opportunities to achieve and maintain this experience leads the individual to develop his, or her skill set, and to search for greater challenges. This process stretches the individual's skills and resources, just like playing sports stretches and strengthens athletes' muscles. The flow experience contributes to the development of the individual by guiding behavior toward challenging opportunities that develop personal resources and resilience. In the study of the importance of *hedonic* (pleasure), *eudaemonic* (meaning) and *engagement* (flow state) orientations to happiness, engagement was considered essential for a Full Life (Peterson, Park, &

Seligman, 2005). And although the lack of all three orientations was associated with low life satisfaction, orientations to *eudaemonia* and engagement were the strongest predictors of higher levels of life satisfaction. This shows how engagement is important to the perception of a fulfilling life.

Csikszentmihalyi and his team at the University of Chicago developed the *Experience Sampling Method* (Csikszentmihalyi & Larson, 1987) to assess flow experiences in everyday life and to understand its role in human trajectory and experience. Researching flow in daily life was important to understand whether it was something rare, exclusive to the artists, scholars and athletes, or whether it was a common and universal experience. They observed that most people experienced flow with some frequency in daily life. Findings in normative populations were similar to those with experts: flow was one of the best psycho-affective experiences in daily life.

Measuring Flow in Daily Life

The development of the Experience Sampling Method represented an important hallmark in the study of the quality of experience in daily life and the interactions between the individual and his environment (Csikszentmihalyi & Larson, 1987; Hektner, Schmidt, & Csikszentmihalyi, 2007; Hormuth, 1992; Larson & Delespaul, 1992). The ESM methodology assesses affective, motivational and cognitive components of experience, and the activities, physical and social contexts in which individuals are involved in everyday life. Participants carry a booklet with experience sampling forms (ESF) and an electronic pager, or programmable wristwatch. They answer an ESF every time they hear the beep at random times, usually during one week. Each ESF includes open-ended questions (e.g., activity, company, location) and Likert-type scales designed to assess psychological functioning (e.g., affective, motivational, cognitive dimensions). Although the ESM shares characteristics with other experience sampling procedures, such as the ecological momentary assessment (EMA - Shiffman, Stone, & Hufford, 2008) and the day reconstruction method (DRM - Dockray, et al., 2010; Kahneman, Krueger, Schkade, Schwarz, & Stone, 2004) its strengths reside in the extent and variety of information gathered while individuals go about their daily lives. The ESM has a random-sampling design, which outlines a rich

portrait of the ebb and flow of everyday life, without the limitations of interval- and event-contingent designs (Scollon, Prieto, & Diener, 2003, for a review of strengths and limitations of different designs). The random design has the advantage of avoiding rehearsal before filling in the report. Because signals are unpredictable, participants pay closer attention to the beeper, which might explain why random-sampling seems to increase compliance in comparison with interval-contingent designs (Jacobs, et al., 2005). Adequate compliance to protocol in ESM studies is evaluated in two ways: filling the ESF in less than 20 minutes after hearing the beep, and having at least 15 valid ESM reports per participant (Csikszentmihalyi & Larson, 1987; Hektner, et al., 2007). This method has been useful to study the daily life of normative and psychopathological populations, and to complement research about therapeutic interventions and psychophysiological function.

The main strength of the ESM is its ecological validity. Participants are prompted to record their experiential states as they interact in their everyday contexts. ESM reports are answered within 1-2 minutes, which avoids contamination by memory and cognitive biases, common in retrospective assessment methods. Instead, reports reflect spontaneous records of psycho-affective states experienced at the time of the signal. The information obtained from momentary and retrospective reports might reflect significant differences. Kahneman and Riis (2005) have shown that the information provided by the *experiencing self* and the *remembering self* are seldom correlated, due to cognitive biases and other memory mechanisms. This means that the self in the moment of experience is not always associated with the self that reports an experience based on its memory and personal interpretations. However, both represent important aspects of the self, with implications for mental and physical health. Differences between personality characteristics obtained through retrospective and online assessment are also found in studies with physiological measures. For example, Steptoe, Gibson, Hamer, and Wardle (2007) observed that a measure of positive affectivity derived from momentary experiences was a better predictor of neuroendocrine and cardiovascular function in daily life than positive affectivity assessed retrospectively. However, the retrospective assessments of personality traits and states cannot be disregarded, because it provides important information about attribution and internalizing processes. Discrepancies between remembrance and

momentary experience were found in studies of flow. In a study with college students, Freire and Matias (2008) observed that reports of flow states differed if flow was assessed in the moment or a week later. Perceptions of control, concentration, challenges and skills were significantly higher than average in the moment and retrospectively. However, there were significant differences in the perception of time and self-consciousness. The experiencing self seemed to perceive time as going faster than usual and feeling more self-conscious than the remembering self. This raises questions about the processes involved in flow states in daily life that contribute to the psychological selection process and the development of personal and professional trajectories.

Another advantage of the ESM is the amount of information it provides. With the ESM, researchers are able to observe within-individual changes and between-individual differences in subjective experience (Hektner, et al., 2007; Nakamura & Csikszentmihalyi, 2002; Schneider, 2008; Scollon, et al., 2003). This differs from retrospective measures in which researchers have a limited one-time assessment of individual psychological functioning. In addition, the inclusion of concurrent physiological sampling increases the understanding of the associations between psychological experiences in daily contexts and physiological functioning.

The main limitations of the ESM concern sample selection, in part because of its demanding characteristics (Hektner, et al., 2007; Scollon, et al., 2003). Many consider the ESM a burdensome and demanding methodology. Therefore, volunteers are usually more motivated and may have personal characteristics that make them more compliant than people who do not volunteer. Furthermore, individuals with low motivation are frequently excluded from the final sample because of lack of compliance. Also, some individual characteristics, for example, illiteracy, blindness or deafness, may present obstacles that prevent or constrain participation in ESM studies.

In sum, the ESM is a good method of assessment of the psycho-affective experience of individuals. The sampling of everyday experience contributes to psychological and psychophysiological investigation in important ways: it examines daily experiences as they occur, without the interference of cognitive biases; it investigates concomitant psychological and physiological functioning, and the

protective and detrimental effects of momentary responses on psychophysiological function. The inclusion of retrospective measures enhances the understanding of attribution and meaning-making processes, how these processes translate into momentary behavior, and how daily experience influences the development of individual personal and professional trajectories.

The Development of the Flow Model

In daily life studies, Csikszentmihalyi and his team operationalized the flow state based on the main conditions for its emergence: the levels of perceived challenges and skills. This measure takes into account the interaction between internal resources (skills) and the opportunities offered by contexts (challenges). Furthermore, it acknowledges that these represent perceptions of the individual and its inner functioning and not objective skills and challenges. The operationalization of the flow state parallels the conditions suggested by the cognitive evaluation theory (CET - Ryan & Deci, 2000) for intrinsic motivation: presence of extrinsic challenging conditions and perceived competence. According to the CET, intrinsically motivated behavior represents an important condition for task engagement and repetition. For example, subjective evaluations of one's skills, health, opportunities and constraints in the environment are better predictors of engagement in exercise and challenging activities. Also, according to the transactional model of stress, the experience of stress in daily life is contingent to primary appraisals of threat, loss, and challenge, and secondary appraisals about one's coping resources (Lazarus & Folkman, 1984; Lazarus, 1999). If the individual perceives adequate behavioral, cognitive and physical resources, the stimuli will be perceived as challenging, instead of a source of harm or threat. Challenging appraisals promote growth, whereas appraisals of harm/threat promote feelings of anxiety and loss.

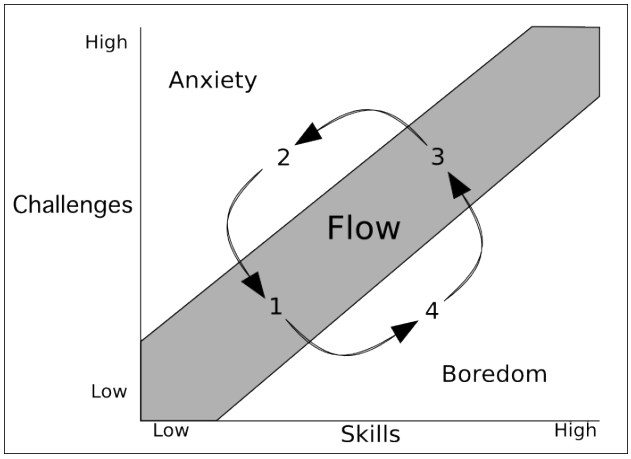

Figure 1 - Flow model based on the continuum of balance between challenges and skills.
Notes. Adapted from Csikszentmihalyi, M., & Csikszentmihalyi, I. S. (1988). *Optimal experience: Psychological studies of flow in consciousness*. Cambridge: Cambridge University Press.

The initial flow model assessed flow based in a continuum of balance between perceived challenges and skills (Figure 1). It was thought that the momentary experience would be enjoyable for the individual as long as challenges and skills matched even at low-levels. However, research showed that situations in which individuals perceive low challenges and skills were not enjoyable. Therefore, the authors developed the four-channel flow model (Figure 2). In this later model, the flow state emerges in activities in which perceptions of challenges and skills are higher than average (Csikszentmihalyi, 1997a, 2002; Csikszentmihalyi & Csikszentmihalyi, 1988). When challenges are higher than skills, individuals are in the anxiety channel, which is experienced as straining and stressful; the apathy channel is characterized by low skills and low challenges and is associated with the worst daily experience: low positive affect, scattered concentration, and lack of motivation. Finally, the relaxation channel refers to contexts in which skills are high, but challenges are low. This channel is associated with low concentration, but high positive affect and motivation; individuals often use this channel to resupply their psychic resources.

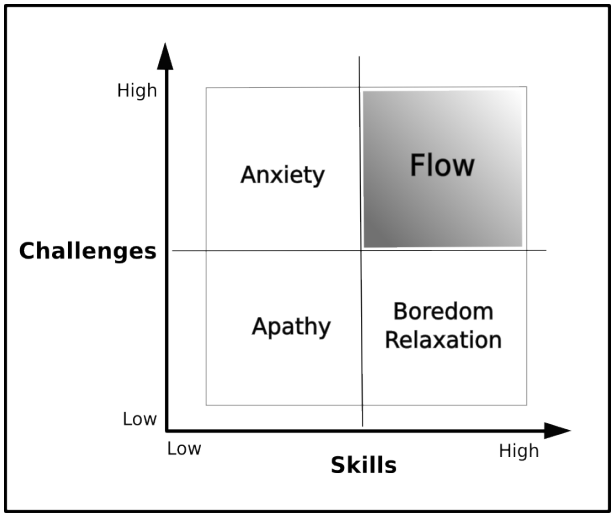

Figure 2 – Four-channel flow model.
Notes. Adapted from Csikszentmihalyi, M., & Csikszentmihalyi, I. S. (1988). *Optimal experience: Psychological studies of flow in consciousness*. Cambridge: Cambridge University Press.

Finally, the team at the University of Milan refined the four-channel model into an eight-channel model, the *Experience Fluctuation Model* (Carli, Delle Fave, & Massimini, 1988; Delle Fave & Massimini, 2005; Delle Fave, et al., 2011; Massimini & Carli, 1988; Massimini & Delle Fave, 2000) (Figure 3). The EFM assesses the quality of experience based on the levels of challenges and skills, and their balance. The EFM presents transitional channels (activation, control, boredom, and preoccupation). These channels represent subtle changes in the quality of experience. For example, activation is a transitional channel between anxiety and flow; therefore, activation might present some characteristics of anxiety and some of flow. This refinement is intended to distinguish characteristics of the experiences associated with the different channels. However, Ellis, Voekl, and Morris (1994) suggested that the original four-channel flow model is more powerful and detects experiential variation and within- and between-individual differences better than the eight-channel model. Also, the creation of categorical variables based either in the standardization at the individual level or at the group-level presents some important methodological issues (Ellis, et al., 1994).

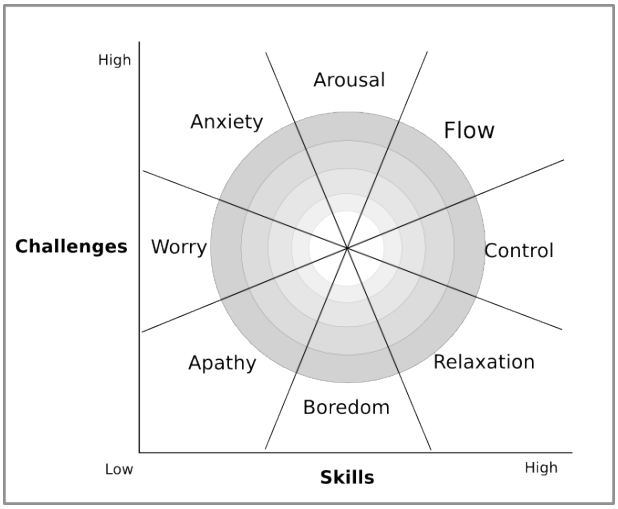

Figure 3 - Experience fluctuation model (EFM).
Notes. Adapted from: Delle Fave, A., Massimini, M., & Bassi, M. (2011). *Psychological selection and optimal experience across cultures* (Vol. 2). New York: Springer.

If the channels are derived from the averages obtained from standardized values at the individual level, they exclude between individual differences. Although the standardization based on intraindividual responses takes into account differences in response styles (i.e., how individuals position themselves on Likert-type scales), it disregards individual perception of levels of challenges and the possibility that some individuals will, in their daily life, consistently pursue higher, or lower levels of challenges, compared to other individuals. In contrast, the creation of variables based on group averages makes the flow experience highly dependent on the averages of each study's sample. As a result, while in one study, experience *i* of participant *j* might be considered a flow state, in another study, using a different sample, that same experience *i* might be considered anxiety, or apathy. There have been attempts to create a continuous variable to assess flow in daily life (Moneta & Csikszentmihalyi, 1996; Schmidt, Shernoff, & Csikszentmihalyi, 2007). Regardless of the variable used, categorical or continuous, increases in challenges and skills seem to be associated with a better affective, motivational, and cognitive experience (Bakker, 2005; Bassi, et al., 2007; Carli, et al., 1988; Csikszentmihalyi, 1997a; Delle Fave & Massimini, 2005; Engeser & Rheinberg, 2008; Freire, 2006; Freire, Fonte, & Lima, 2007; Moneta, 2001; Rogatko, 2009; Schmidt, et al., 2007). However, the balance between challenges and skills does not always predict a better psycho-affective experience in all kinds of

activities and contexts (Delle Fave, et al., 2011; Engeser & Rheinberg, 2008; Moneta & Csikszentmihalyi, 1996; Schmidt, et al., 2007).

Is flow more than the balance between challenges and skills?

The flow state relies heavily on the presence of high challenges, or opportunities for action and a matching set of personal skills. High challenges tend to require the individual to fully engage physical and mental resources to respond adequately to the situation. Lower challenges do not elicit full engagement, although they can be associated with pleasant and enjoyable situations. One of the most important factors in how challenges are experienced is the perception of skills the individual possesses to face those challenges. If skills are too low, individuals experience anxiety and threat; if skills are too high, they feel bored and apathetic. However, although these are essential conditions for the flow state, there has been some contestation as to whether they always identify contexts in which individuals experience intense engagement and enjoyment. For example, Japanese students seem to experience more enjoyment when challenges are slightly higher that skills compared to Chinese and U.S. American students, who experience more enjoyment in situations in which skills are slightly higher than challenges (Moneta, 2001). Therefore, we should consider intra- and inter-individual differences in the experience of contexts with balanced levels of challenges and skills when assessing the flow state in daily life.

The "*work paradox*" was one of the first indications that the balance between challenges and skills did not always identify flow in daily life. When asked about activities in which engagement is high, people often identify study and work activities as sources of flow experiences (Freire & Matias, 2008; Massimini & Carli, 1988; Matias & Freire, 2009). In daily life studies, productive activities present situations of balance between high challenges and skills more often than other daily activities, although positive affect and motivation are usually lower. Compared to productive activities, leisure activities are less often associated with high balanced experiences, but they are often associated with high motivation and positive affect. However, balanced experiences in leisure are associated with greater motivation, concentration, and positive affect than any other activity in daily life (Csikszentmihalyi & Lefevre,

1989; Freire, 2006; Freire, et al., 2007; Lefevre, 1988). These findings have been explained in terms of cultural meaning-making processes, interest, the availability of internal resources, the perceived importance of the activities, and personal characteristics.

There is a cultural meaning attributed to work and leisure activities that partly explains the work paradox. Especially in Western cultures, people regard work as effortful and associate enjoyment with being away from work. Because of this, people often wish they were in leisure when they are working, even if most of the opportunities for engagement and growth are present in the work environment. A clear example of this attribution process was observed in a study in rural Italy (Delle Fave & Massimini, 1988; Delle Fave, et al., 2011). Older villagers associated flow states with work and barely recognized differences between productive and leisure activities. They were happy to work, they enjoyed it, and they wished to continue to work and replicate flow experiences in this context. However, their grandchildren, educated and who had integrated the values of modern Western culture, did not share this idyllic positive view of work. These cultural processes may explain why people let opportunities for engagement and growth pass them by in productive contexts.

Another example comes from a study comparing Montessori and traditional students (Rathunde & Csikszentmihalyi, 2005a). Montessori students have a fair amount of autonomy and incentive to explore personal interests. In contrast, traditional students are usually passive recipients of educational information and often perceive lack of control and interest over what they learn. While Montessori students enjoyed challenging tasks and productive activities more than other activities, traditional students showed the opposite pattern. This shows how autonomy and the possibility to express and act over personal interests play a vital role in the appreciation of challenges and productive activities. In challenging activities, interest and motivation can shift the perception of effort from effortful to effortless. While effortful activities are avoided and experienced negatively due to the depletion of physical and mental resources, effortless activities strengthen the sense of self and are sought after by individuals. Intense experiences of flow, interest, and engagement have been associated with enjoying work and study, spending more time in these activities, and better performance (Allison & Duncan, 1988; Asakawa & Csikszentmihalyi, 1998a;

Bakker, 2005; Engeser & Rheinberg, 2008; Lefevre, 1988; Lima & Freire, 2009). However, if high challenges and skills are accompanied by low enjoyment, then contexts are experienced as effortful, attention is scattered and there is a excessive depletion of energetic resources. Consequently, individuals avoid these experiences and activities whenever possible. Therefore, although challenges and skills represent fundamental conditions of flow, they are proxy conditions and do not ensure that a flow state will follow. The measure of balanced flow does not take into consideration personal interpretation, autonomy, and interests, and it does not consider possible limitations related to attentional deficits and personal characteristics.

The availability of internal attention resources, or psychic energy, can determine whether engagement follows a balanced experience. Intense engagement requires the mobilization and regulation of attentional resources. Regretfully, attentional resources exist in limited supply, which makes it impossible to be in a constant flow state. Even if personal skills match the challenges faced, the individual can find it difficult to concentrate and to regulate attention processes if attentional resources are exhausted. In productive contexts, individuals have frequent opportunities to participate in challenging activities, although these often disregard levels of personal energetic resources. After a challenging event, attentional and self-regulatory resources are depleted and it becomes difficult to regulate behavior and attention (Hommel, 2011). If a student experiences flow in a class, he might not have enough attentional resources to re-experience it in the next class, regardless of how challenging the individual perceives the task to be and how skillful he perceives himself to be.

The importance of the activity for the individual's immediate and future goals also influences the experience of flow. The flow state is an autotelic experience, an experience that is perceived as a reward in itself. Therefore, flow activities are not necessarily associated with important life goals other than self-realization.

Engeser and Rheinberg (2008) observed that the levels of balance between challenges and skills were not always associated with the experience of engagement. The importance given to the activity mediated the association between levels of balance and engagement. In activities that were not perceived as important to personal goals, the balance between challenges and skills predicted the intensity of engagement;

in activities perceived as important, the balance between challenges and skills did not predict engagement. Furthermore, while activities that are important for individual's needs create vitality and energy, activities that are not important, deplete energetic resources and are experienced as effortful (Ryan & Deci, 2008).

Finally, certain personal characteristics are associated with differences in the experience of flow. For example, individuals with attention disorders are not able to focus and sustain attention in one task and, as a consequence, they find it difficult to experience flow. Individuals with high maladaptive perfectionism, who are highly self-conscious about other people's opinion of their behavior and performance cannot achieve harmony of thoughts, goals and emotions (Csikszentmihalyi, 2002). Implicit theories about the self will also foment approach or avoidance behaviors toward challenging situations, influence the way individuals perceive their own skills, and impact the kind of goals individuals set for themselves (Blackwell, Trzesniewski, & Dweck, 2007; Dweck & Leggett, 1988; Elliot & Harackiewicz, 1996; Elliott & Dweck, 1988; Grant & Dweck, 2003). For example, individuals who hold entity theories about the self need to measure and evaluate their performances. They set performance goals and avoid challenging situations if they perceive there is a chance of failure. Incremental theorists enjoy developing new skills, they set learning goals, and will often approach challenges - and possible failures - as opportunities for development. Individuals who focus on performance goals experience significantly less intrinsic motivation and involvement in tasks, even if their performance is as good as their counterparts who value performance learning and mastery goals. Also, achievement motives and the perceived importance of the activity interact in the experience of flow.

In activities perceived as highly important, individuals with the achievement motive "*hope of success*" experienced flow when faced with balanced experiences; while individuals with the achievement motive "*fear of failure*" did not (Engeser & Rheinberg, 2008). In the study of autotelic individuals, Adlai-Gail (1994) noticed that autotelic and non-autotelic individuals experienced balanced flow differently: non-autotelic individuals experienced these contexts as more stressful and preferred to be in situations in which skills exceeded challenges. This finds a parallel with individuals with "*fear of failure*" motives: challenging situations, even if met with adequate skills, might represent a threat to a delicate sense of self. Therefore, these individuals will try

to avoid these situations even at the cost of hindering personal development and growth. We will return to the discussion about personal characteristics and the flow experience further on in this chapter.

The Flow State and Daily Contexts

The study of flow in daily life is not complete if we do not know how it unfolds in daily contexts: Who are we with when we experience flow? What kind of activities are we involved in? Is the flow state different from one person to the next? In the current research project we investigated the experience of flow in the daily life of college students.

Students face several challenges as they enter college: moving from their parents' home, parting from old friends, creating a new social network, and dealing with new academic demands. These challenges can threaten personal feelings of security and increase the need for acceptance and comfort. It is common for students to experience transient feelings of sadness and loneliness, especially in their first year (Furr, Westefeld, McConnell, & Jenkins, 2001). However, failure to adapt to college life can have life enduring consequences and has been associated with loneliness, depression, suicidal ideation and attempts (Dyson & Renk, 2006; Furr, et al., 2001; Gerdes & Mallinckrodt, 1994; Lackovic-Grgin, Penezic, & Soric, 1998; Vredenburg, Obrien, & Krames, 1988; Wei, Russell, & Zakalik, 2005).

In some studies, staying close or at the parents' home was associated with better adaptation to college, less feelings of loneliness and depressive symptoms (Gerdes & Mallinckrodt, 1994; Moller, Fouladi, McCarthy, & Hatch, 2003), although other studies found that having more colleagues than family members in their networks was associated with increased adaptation to college (Hays & Oxley, 1986). Strong cultural differences in family life and interactions can be associated with differences in well-being. A comparison between Italian and American emerging adults showed that while Italian students had good relationships with their parents if they lived closer to them, the same held true for American students who lived the furthest away from their

parents (Arnett, 2000). While Italians move away from home later in life - usually as they start their own family - American students seem to search for independence from their parents earlier. In the context of adaptation, closeness to parents and supportive relationships can have important implications on mental well-being in this context. Taking into account the challenging adaptation period in the life of college students, we chose to investigate two of the most challenging daily contexts in their everyday lives – daily solitude and study activities – and how engagement can improve their psycho-affective experience.

Solitude and Flow: Can Engagement turn a Negative Experience into a Positive One?

Humans are intrinsically social beings. Engaging in social interactions and cooperation increases the likelihood of survival of the individual and the species. As a result of the evolutionary process, we are hard-wired to avoid being alone, isolated from human contact. Mental and physical pain experienced in solitude is meant to motivate the individual to search, maintain, and repair social relationships (Cacioppo, et al., 2006). For example, children experience heightened cortisol levels when alone, even in the absence of negative affect (Gunnar & Donzella, 2002). This social regulation of neuroendocrine function stimulates behaviors to search for human contact in childhood, as feelings of loneliness do in adulthood (Cacioppo, et al., 2006). In the long-term, chronic social isolation has been associated with psychological and physical adverse effects (Cacioppo, et al., 2000; Cacioppo & Hawkley, 2009; Cacioppo, et al., 2002; Hawkley & Cacioppo, 2003a; House, Landis, & Umberson, 1988; Stillman, et al., 2009). Although most of the times individuals avoid solitude, positive solitude is associated with some of the most engaging, creative, and productive experiences in daily life.

Solitude is defined as "the quality or state of being alone or remote from society" (*Webster's Third New International Dictionary, Unabridged*. Merriam-Webster, 2002. http://unabridged.merriam-webster.com). Solitude refers to the context in which there is no immediate possibility for social interactions. The individual is isolated from possible exchange of information and affect that social interactions entail, and the

external stimulation that keeps consciousness orderly (Larson, 1990). Therefore, solitude is often associated with chaotic states of mind, scattered attention, and feelings of sadness and loneliness, even when solitude is voluntary (Brown, 1992). At the same time, solitude is a context in which individuals are free from social constraints, demands, and expectations, thus free to think and act without the pressures of social scrutiny. In adolescence, spending a moderate time alone has been associated with better psychological adjustment and well-being (Larson & Lee, 1996; Larson, 1997). This finding relates to the opportunity that solitude provides to integrate information about the world and develop a coherent sense of self. During college, solitude can be an important context in which to define life goals and build personal and professional trajectories.

Positive solitude has been associated with such enterprises as creative activities, sailing, mountain climbing, and writing (Csikszentmihalyi, 2005; Larson, 1988; Logan, 1988; Long & Averill, 2003; Long, Seburn, Averill, & More, 2003; Macbeth, 1988). Positive solitude is a context in which the mind is able to expand, virtually touching fantasy, without worrying about other people. Although positive solitude is seldom associated with heightened positive affect, it is associated with increased motivation, concentration and loss of self-consciousness (Csikszentmihalyi, 1997a, 2002; Larson & von Eye, 2010; Larson, 1990). Although being in flow alone is not as enjoyable as flow with other people (Walker, 2010), working in solitude has been associated with some of the greatest accomplishments in the arts, science and literature. In fact, laboratory studies have shown that individuals seem to perform better in complex and difficult tasks when they are alone than with other people. People are able to concentrate better in solitude, away from distractions and worries about other people's judgments. However, positive solitude can only be achieved by the feeling of connection with others, a strong sense of self, and the certainty of availability of social support (Long & Averill, 2003). Most of all, positive solitude has been associated with activities that engage the individual and mobilize physical and mental resources: the task fills all mental space and brings order to consciousness. However, few studies have focused on daily solitude and the role of flow in this context.

Study Activities and Flow: Privileged Contexts to Experience Engagement?

Study activities present optimal opportunities for the acquisition of knowledge, the development of skills, and the experience of flow (Csikszentmihalyi & Lefevre, 1989; Delle Fave & Massimini, 2003; Delle Fave, et al., 2011; Lefevre, 1988; Lima & Freire, 2009). Study activities offer incremental levels of challenges that match developing skills, they have clear proximal goals, and provide immediate feedback over performance. Also, study activities represent opportunities to develop a broad knowledge about the world, culture, and develop goals for the future.

Regardless of the positive opportunities of learning contexts, study activities are often associated with negative psycho-affective experiences: low positive affect, enjoyment, and motivation (Allison & Duncan, 1988; Csikszentmihalyi, 2002; Delle Fave & Massimini, 1988; Delle Fave, et al., 2011; Lefevre, 1988; Rheinberg, Manig, Kliegl, Engeser, & Vollmeyer, 2007; Salanova, et al., 2006). However, this pattern is more often seen in passive (e.g., lectures) than in active class work (e.g., group work) and schoolwork outside the classroom (Delle Fave, et al., 2011; Schernoff, et al., 2003). In active class work, students feel they are in control, they feel confident about their skills, and perceive these activities as relevant to their goals. Work outside the classroom also fosters control and can be perceived as self-determined. Passive class work, on the other hand, is perceived as non-self-determined and experienced as boring. Research has shown that actions motivated in self-determined way are conducive to flow states, better academic performance, persistence, and positive emotions (Bandura, 2001; Kowal & Fortier, 1999; Ryan & Deci, 2000); the opposite is found in non-self-determined activities. But cultural attributions can influence the way perceptions of self-determined and non-self-determined behaviors are associated with the experience of study.

Cross-cultural research shows that the work paradox is mostly observed in Western cultures, compared to non-Western cultures. For example, in a study comparing Nepalese and Italian students, Delle Fave and colleagues (2011) observed that Nepalese experienced flow in study activities more often than in leisure, whereas the reverse was true for Italian students. In addition, Nepalese students enjoyed study, they were highly engaged, and identified short- and long-term goals in the learning context. Although Italian students identified long-term goals in study activities, they were more

involved in other activities. Another comparison between Asian Americans and Caucasian Americans showed that Asian Americans tend to be involved in study activities more often (even in solitude), they enjoy these activities more, they feel more active, in control, and better about themselves than Caucasian American students (Asakawa & Csikszentmihalyi, 1998a, 1998b, 2000; Nakamura, 1988). Differences in the importance given to study, the encouragement of family, and parenting styles seem to play a fundamental role in the interpretation and meaning given to study activities as contexts of growth and development.

More than cultural differences, it seems that the encouragement and importance attributed to study activities foster a combination of intrinsic and extrinsic motivations and promote a sense of self-determination regarding the choice of activities in which to participate (Csikszentmihalyi, 1997a, 2002; Rathunde, 1988, 1996b). In turn, students perceive continuity between immediate and future rewards, and enjoy study activities more than students who do not perceive such continuity (Adlai-Gail, 1994; Asakawa & Csikszentmihalyi, 1998b). Enjoying study activities has been associated with better academic achievement, a more congruent vision of the link between immediate activities and long-term goals, and spending more time in study (Allison & Duncan, 1988; Asakawa & Csikszentmihalyi, 1998a; Bakker, 2005; Engeser & Rheinberg, 2008; Lefevre, 1988). Also, people who enjoy being involved in productive activities are more likely to enjoy their work and daily activities outside of this context. Overall, enjoying productive activities can develop individual resources and resilience and prevent burnout and dropout.

The Autotelic Personality

Everyday experience is not simply the result of the individual's reaction to contexts; it is also the result of the interaction between individual characteristics and situational factors. The way each context is associated with different behaviors, emotions, and thoughts relates to the characteristics of the situation (e.g., challenges), the individual (e.g., positive affectivity, neuroticism, optimism), and personal

meanings (e.g., threat vs. opportunity). The flow theory suggests that individual characteristics explain the propensity to experience flow. The autotelic personality describes individuals who have greater predisposition to experience flow in daily life, either because of genetic endowment, physiological advantages, or social and educational factors during early development (Adlai-Gail, 1994; Asakawa, 2010; Csikszentmihalyi, 1993, 1997a, 2002; Inghilleri, 1999; Matias & Freire, 2009; Nakamura & Csikszentmihalyi, 2001, 2002; Rathunde & Csikszentmihalyi, 2005b).

Autotelic individuals seem to experience greater enjoyment in life: they are intrinsically motivated, have greater creativity, prefer challenging situations that provide them opportunities for learning and growth, and have a seemingly never-ending supply of energy. These characteristics seem to be the result of nature and nurture processes during development of autotelic individuals' lives. For example, they seem to have more physical energy and perceive themselves as being healthier. Individuals with high intrinsic enjoyment also have better attention control and possibly better attentional resources. However, these might result from an active mental life and a healthier lifestyle. Some studies have associated happiness with the autotelic personality (Asakawa, 2010; Nakamura & Csikszentmihalyi, 2002). However, it seems none has looked at the associations between the autotelic personality, negative affectivity, and variations in affect in daily life.

Research on happiness shows that individuals who experience higher levels of positive affect, lower levels of negative affect, and stable levels of affect in daily life are happier and more content that individuals who fluctuate from highly positive to highly negative affective experiences (Diener, Lucas, & Oishi, 2002). Positive affectivity buffers the effects of negative contexts, and is associated with a myriad of psychological resources (e.g., optimism, originality, sociability, energy) that contribute to promote personal and professional success (Lyubomirsky, King, & Diener, 2005). In addition, these personal characteristics have been associated with better physiological functioning, and health and longevity (Adam & Gunnar, 2001; Bohnen, Nicolson, Sulon, & Jolles, 1991; Bostock, Hamer, Wawrzyniak, Mitchell, & Steptoe, 2011; Bunting, et al., 2000; Chida & Steptoe, 2008; Danner, et al., 2001; Diener & Biswas-Diener, 2008; Etnier, 2008; Hansen, et al., 2010; Harte, et al., 1995; Howell, 2009; Lai, et al., 2005; Matias, Nicolson, & Freire, 2011; O'Donnell, Badrick, Kumari,

& Steptoe, 2008; Polk, Cohen, Doyle, Skoner, & Kirschbaum, 2005; Pressman & Cohen, 2007; Pressman, et al., 2009; Pruessner, et al., 2005; Ryff & Singer, 2002; Seeman & Lewis, 1995; Steptoe, Dockray, & Wardle, 2009; Taylor, 2011; Taylor, et al., 2003; Tsuda, et al., 2008).

Nurture also plays an important role in the development of the autotelic personality. The study of families, schools, and friends of autotelic individuals show that these tend to share some similarities (Inghilleri, 1999; Nakamura, 1988; Nakamura & Csikszentmihalyi, 2001; Rathunde, 1989, 2001; Rathunde & Csikszentmihalyi, 2005a). They provide complex environments in which individuals find support with autonomy, challenges, and adequate expectations. They foster personal interests, but focus on discipline in an authoritative rearing style. Overall, these environments provide opportunities for self-expression and action, exploration of interests and engagement. The cumulative effects of these experiences of flow improve self-esteem and self-efficacy beliefs. Moreover, they promote the development of learning motives and consequently, autotelic individuals interpret challenges as opportunities for learning and development and not as threats to their sense of self. Failures are not interpreted as threats, but challenges to overcome through the development of competence and skills. This constant quest for learning and development finds a parallel in studies of creative individuals, experts and individuals with high need for cognition and trait absorption (Cacioppo & Petty, 1982; Cacioppo, Petty & Kao, 1984; Cacioppo, Petty, & Morris, 1983; Wild, Kuiken & Schopflocher, 1995). Individuals who excel in various fields are characterized by intense complexity and flexibility in cognitive and behavioral functioning, and intense passion for their field of interest (Araújo, 2010; Csikszentmihalyi, 1996, 1997a). Although they usually mention an early interest in the field of current expertise, they also report spending several hours, weeks, months and years intensely studying and developing their skills. Richard Feynman, the 1965 Nobel Prize laureate in Physics, expressed this idea in an interview for a BBC series:

> "*You ask me if an ordinary person, by studying hard, would get to be able to imagine these things, like I imagine them. Of course! I was an ordinary person who studied hard! There's no miracle-people! It just happens they got interested in this thing, and they learned all this stuff. (…) There's no talent (…) without practice, and reading, and learning, and study.*" (Sykes, 1983)

Studies of experts, from athletes to academic scholars, show that the development of expertise takes time, discipline, effort, and intense engagement in the field of interest (Araújo, 2010; Csikszentmihalyi, 1996, 1997a; Ericsson & Lehmann, 1996). The strenuous, disciplined work, and deliberate practice lead to the development of flexibility and fluidity in patterns of thought related to the field of interest. For example, a study of adolescents (Matias & Freire, 2009) showed that autotelic and non-autotelic individuals differed significantly in how the flow state starts. While autotelic adolescents experienced flow spontaneously as they begun the activity, their less autotelic counterparts usually relied on external cues from other people (e.g., compliments), conditions (e.g., need to have silence), or feedback about a good performance (e.g., score a goal). It seems that the frequent experience of flow creates an internal state that offers autotelic individuals the ability to experience flow spontaneously in any activity, unlike less autotelic adolescents. The need for positive feedback and external cues from the physical and social environment may also explain why these adolescents experience less flow in their daily life experiences. Moreover, autotelic individuals make experiential course corrections to re-experience states of interest and flow (Eisenberger & Rhoades, 2001).

In fact, although autotelic individuals search for opportunities of action in their context, this does not always translate in participation in different activities. The associations between the autotelic personality and time allotment has yield diverging results: some authors show that autotelic individuals spend more time in active and productive activities than non-autotelic students (e.g., Adlai-Gail, 1994), whereas

others did not find significant differences in activities reported by autotelic and non-autotelic students (e.g., Asakawa, 2004). However, different studies show that, regardless of the activity, autotelic students show marked differences in subjective experience (Adlai-Gail, 1994; Asakawa, 2004; Moneta, 2004). Finally, autotelic individuals have an intense need to understand the world and to integrate new ideas into a comprehensible internal model, they enjoy solving problems, dealing with challenges, and thinking about the world.

Overall, autotelic individuals are the epitome of how enjoyment and engagement in daily life contribute to the positive development of the self and culture. Autotelic individuals search for opportunities for engagement in their everyday lives, even if they include routine tasks in an assembly line (Csikszentmihalyi & Beattie, 1979). As autotelic individuals experience flow states frequently, they build their internal resources, increase their sense of self-efficacy and positive affectivity. Positive emotions in daily life increase complexity by broadening mental and behavioral repertoires and motivating approach behaviors to new problems and social contexts. In turn, the increase in positive emotions, such as curiosity, promotes the experience of flow and gradually develops resilience to stress and complexity of mental structures (Fredrickson & Joiner, 2002). Autotelic individuals seem to have *life themes* that are global and more socially oriented than less autotelic individuals. They approach problems present in the society and culture to which they belong. They are oriented towards their communities and help promote opportunities for development within their contexts. Overall, the study of autotelic individuals is important to understand the personal and contextual processes that promote good mental and physical functioning.

The Assessment of the Autotelic Personality

The study of autotelic individuals sheds light into the processes involved in the promotion of an engaging life. The assessment of the autotelic personality has relied on two main methods: the Flow Dispositional Scale (FDS - Jackson & Eklund, 2004) and the frequency in which participants report being in flow during the ESM assessment week(s).

The FDS is a retrospective scale developed within the field of sport psychology. It assesses the frequency with which individuals experience the nine dimensions of flow in relation to a specific activity or field (Jackson & Eklund, 2004). Although useful in populations that spend most of their time in a specific activity (e.g., professional athletes), it has limited value for the evaluation of individuals who are involved in a wide range of activities in their daily lives. For example, a participant might be categorized as autotelic in sports, but not in academic activities.

The ESM, on the other hand, assesses every balanced experience, regardless of the activities in which it occurs. It creates a broader picture of the frequency and variety of experiences of flow in daily life. Most studies assess the autotelic personality based on the relative frequency with which participants report being in flow (Adlai-Gail, 1994; Asakawa, 2010; Nakamura & Csikszentmihalyi, 2002). In most studies of the autotelic personality, flow is operationalized as experiences in which participants perceive levels challenges and skills above the group mean. However, the use of the group mean as a cut-point for the measurement of flow makes it highly dependent on the sample used. Consequently, the categorization of autotelic vs. non-autotelic individuals will be subject to the individuals in the sample used in a particular study. Measuring flow based on the intraindividual mean of perceived challenges and skills can also be problematic: there is a probability that 25% of each individual's beeps will be assessed as flow and the intra-individual measure of flow does not distinguish inter-individual differences. This issue could only be solved if standardized measures for "average challenge and skill" according to gender, age, and developmental stages, among others, were created.

To address the lack of standard measures, we believe that the autotelic personality can be measured based on individuals' internal functioning and experiences. The flow theory proposes that autotelic individuals experience greater involvement, effortless attention, motivation and positive affect, regardless of the opportunities and challenges present in their environment (Nakamura & Csikszentmihalyi, 2002). Also, autotelic individuals find meaning in activities that others do not find meaningful and experience greater motivation, involvement and happiness in their daily tasks. Furthermore, spending time in flow has a carry-over effect to other daily contexts (Lefevre, 1988; Nakamura & Csikszentmihalyi, 2002). For example, in a usually

negative context, such as solitude, autotelic individuals should have a better psycho-affective esperience than less autotelic individuals. However, the similarities between autotelic personality, trait absorption and need for cognition suggest that, although autotelic individuals tend to be happier, the autotelic personality might be relatively independent of trait affectivity and other personality measures, such as neuroticism and extraversion (e.g., Wild et al., 1995). The autotelic personality, like trait absorption, is associated with characteristics that, although promoting positive affect and growth in daily life, seem to measure an overall state of higher cognitive activation and involvement in daily life contexts.

Previous attempts to assess trait indexes based on the aggregation of measures obtained in experience sampling studies (e.g., positive affectivity, negative affectivity) showed significant differences in the prediction of psychological and physiological responses to daily contexts (Csikszentmihalyi & Hunter, 2003; Matias, et al., 2011; Steptoe, Owen, Kunz-Ebrecht, & Brydon, 2004). Therefore, we propose that an index based on the aggregation of positive affect, cognitive efficiency, and motivation would more fully express the overall predisposition to experience higher engagement and increased cognitive activation and intrinsic motivation across multiple daily life contexts.

Chapter 2: The Psychophysiology of Daily Life

"It is as if evolution has built a safety device in our nervous system that allows us to experience full happiness only when we are living at 100%--when we are fully using the physical and mental equipment we have been given."

Mihalyi Csikszentmihalyi

How do daily life experiences influence physiological function and health? The study of psychophysiology in daily life experience has focused mainly on the negative experiences, such as daily hassles, stress, and negative affect. This might be associated with the way positive and negative experiences impact physiological function and human behavior. The study of positive characteristics might be more difficult than that of negative characteristics due to the different systems they activate. For example, positive and negative emotions are relatively independent, which can be seen in differences found in their psychological expression and neurological activation.

According to the broaden-and-build theory of emotions (e.g., Fredrickson, 2004), positive emotions are harder to study than negative emotions. Negative emotions are associated with clear action-repertoires and have evolved to deal with momentary threats that require a fast resolution. Extreme levels of negative emotions, such as anxiety, sadness, or loneliness that surpass the individuals' coping abilities are associated with psychopathology and poor health outcomes. Instead of narrowing the individual's attention and actions, positive emotions promote cognitive flexibility, creative problem solving, and are associated with less predictable behaviors and approach behaviors. Positive emotions build internal resources that lead to better coping mechanisms when confronted with stressful contexts, which in turn lead to the development of greater psychological resources and more positive emotions. The circular effect between positive emotions and the development of psychological resources has a long-lasting, cumulative effect on the development of personal structures. Their impact on physiology and health may be harder to observe; however, the cumulative effect of positive personality traits and life experiences may emerge as individuals grow and age.

A growing body of literature has reported significant associations between cardiovascular, immune, and neuroendocrine function in positive aging. The natural decay processes related to aging offer a privileged view of the associations between greater well-being, optimism, and social support, and physical and psychological outcomes. Steptoe and colleagues (2004) studied the associations between happiness and cardiovascular, inflammatory and neuroendocrine variables in a sample of elderly men and women. They observed that the happiest individuals had the lowest levels of cortisol and fibrinogen response to stress tasks. Three years later, they evaluated the same individuals and found the same associations between happiness and cortisol, and a new association between happiness and lower blood pressure. The longitudinal design allowed researchers to find an association that would have otherwise been missed. However, the development and ease of assess to new techniques has lead to findings that go beyond individual differences and investigate individual responses in laboratory settings and in daily life. The introduction of these new methods in the field of positive psychology has created the opportunity to study psychophysiological functioning within its aims.

Allostasis and Allostatic Load

Everyday experiences and contexts influence psychological experience, behavior, and physiological function. Theories of toughness suggest that being exposed to stressors and the subsequent activation of physiological mediators can develop better psychological and physiological coping responses to stress (Dienstbier, 1989). Animal models show that stress in early life is associated with better functioning in situations that induce high corticosterone in adulthood (Oomen, et al., 2010). In humans, however, most research focuses on the associations between adverse early life contexts and psychopathology. Adverse life contexts are associated with the development of psychopathology, such as post-traumatic stress disorder or depression, in particular in individuals with low resilience and emotional regulation (Giesbrecht, et al., 2009).

Differences in the sensitivity to stress and development of psychopathology are related to genetic predispositions, as well as to environmental conditions and experiences.

The process of allostasis regulates the physiological processes involved in the adaptation to environmental conditions and refers to the process through which the human organism adapts to external and internal stimuli to maintain homeostasis (McEwen, 2000, 2002, 2006, 2008). Allostasis activates and modulates physiological systems such as the autonomous nervous system (ANS) and the hypothalamic-pituitary-adrenocortical (HPA) axis as mediators that prepare the organism to cope with daily situations. In certain circumstances, these responses are adaptive and protect the organism. In others, there is an inefficient or dysregulated response that might lead to pathological symptoms.

In addition, the existence of excessive stress markers is conceptualized as allostatic load. The organism suffers wear and tear from its physiological systems if the activation in response to stress is chronic, dysregulated or inefficient (McEwen, 2000, 2008). Allostatic load is defined as a high activation of several stress-responsive systems (e.g., cortisol, blood pressure, cholesterol), which can affect brain plasticity and neurogenesis, impair cognitive performance, and lead to cognitive decline in the aging process (McEwen, 2002). In a prospective study, Juster and colleagues (2011) observed that an index of allostatic load - plasma cortisol, total cholesterol, high-density lipoprotein cholesterol, triglycerides, glucose levels and blood pressure – was associated with depressive symptoms 3 years later. Allostatic load is also associated with the development of mental and physical pathology, such as the suppression of the immune system, chronic fatigue, cardiovascular disease, reduction of the volume of the hypothalamus, and increase in the volume of the amygdala, which are associated with cognitive impairment and alterations in mood regulation (McEwen, 2000, 2002, 2006, 2008; Wiedenmayer, et al., 2006).

Momentary activation of different physiological systems impacts affect, attention, memory and performance differently according to individual characteristics such as age and gender. For example, young women have lower levels of cortisol, higher heart rate, and lower blood pressure than young men in response to stress tasks (Smeets, Dziobek, & Wolf, 2009; Schwabe, Bohringer, Chatterjee, & Schachinger, 2008; Wolf,

Schommer, Hellhammer, McEwen, & Kirschbaum, 2001) These differences have been explained by the protective effects of estrogen and the tendency of women to adopt a "tend-and-befriend" or affiliative approach, in contrast to the "fight-or-flight" approach commonly adopted by men (Smeets, Dziobek, et al., 2009; Taylor, Dickerson, & Klein, 2002; Taylor, et al., 2000). However, elderly women seem to be more responsive to stress, exhibit higher cortisol levels and blood pressure reactivity, and show greater cognitive decline than elderly men (Seeman, Singer, & Charpentier, 1995). These differences are not always observed in pre-menopausal women, or those using hormone replacement treatment, thus confirming the protective role of estrogen in relation to the stress response (Blumenthal, et al., 1991; Stoney, 1992). Regardless of the deleterious effects of the chronic and repeated activation of ANS and HPA axis on the organism, their functioning and response to daily life stimuli represent important advantages for human adaptation and survival.

In the current research project we were interested in the daily experiences and contexts that promote a better physiological function. In particular, we were interested in the associations between engaging experiences, the propensity to experience engagement in daily life, and cortisol, an index of HPA axis activity. We expect that the investigation of daily life experiences and positive individual traits, may offer new insights into the adaptive processes that promote optimal mental and physical function.

Cortisol

Cortisol is the end-product of the HPA axis and the main glucocorticoid in the human organism (reviews, Nicolson, 2007; Soares & Alves, 2006). The HPA axis is one of the main systems involved in the adaptational response of the organism to stimuli from the environment. Cortisol has a distinct daily rhythm, with a steep increase in the first 30-40 minutes after waking. After the first hour after waking, cortisol levels start to decline throughout the day, reaching a low point between 10pm and 4am. Cortisol is released in a pulsatile fashion throughout the day, as part of its daily rhythm and whenever the organism faces a demanding situation. When the

individual faces external and internal stressors, the hypothalamus releases corticotropin-releasing hormone (CRH) and arginine vasopressin (AVP). CRH acts with the AVP in the pituitary to release opiomelanocortin (POMC) peptide in the pituitary. POMC creates the adrenocorticotropic hormone (ACTH) that is secreted into the bloodstream, and stimulates the adrenal release of cortisol.

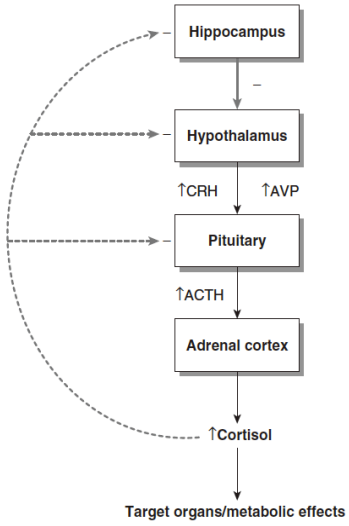

Figure 4 - Schematic overview of the hypothalamic-pituitary-adrenocortical (HPA) Axis

Note. CRH = corticotropin-releasing hormone, AVP = arginine vasopressin, ACTH = adrenocorticotropic hormone. Dashed lines indicate negative feedback effects. *Source:* Nicolson, N. A. (2007). Measurement of cortisol. In L. J. Luecken, & L. C. Gallo (Eds.), *Handbook of physiological research methods in Health Psychologyogy* (pp. 37-74). London: Sage Publications, Inc.

The HPA axis function is regulated by a negative feedback system that controls the concentration of cortisol in the system and the immediate needs of the organism. Mineralocorticoids (MR) and glucocorticoid (GR) receptors exist in vital parts of the brain to prepare for and to facilitate the recovery of the organism after demanding situations. After the individual is able to successfully respond to the situation, cortisol is metabolized in the liver and eliminated within 2 hours after its release, returning to baseline levels (Nicolson, 2007; Peters, et al., 2004; Soares & Alves, 2006). Increased levels in the face of an acute stressor and recovery to baseline levels characterize the adaptive and healthy cortisol response after dealing with the stressor. This response is seen even in sub-clinical anxiety, in which other adverse effects (e.g., suppression of

the immune system) do not accompany the HPA axis activation (Barak, 2006). Failure of cortisol to return to baseline levels and the chronic activation of the HPA axis are associated with negative psychological and physical outcomes such as fibromyalgia, chronic fatigue, hyper- and hypocortisolism, sleep disturbances and psychopathological states of depression and anxiety disorders (McEwen, 2005, 2006, 2008; Miller, Chen, & Zhou, 2007; Nicolson, 2007; Nicolson & van Diest, 2000; Raison & Miller, 2003); also, personality traits (e.g., loneliness, negative affectivity) and life experiences in children and adolescents (e.g., interpersonal conflict) are associated with alterations in cortisol basal levels (Adam, Klimes-Dougan, & Gunnar, 2007; Cacioppo, et al., 2000; Steptoe, et al., 2004; Uchino, Cacioppo, & Kiecolt-Glaser, 1996).

One of cortisol's main functions is the psychobiological response to stress. It mobilizes energetic resources used in the response to stress through glucogenesis. However, cortisol is also associated with the activity and regulation of other physiological systems: it stimulates the segregation of anti-inflammatory cytokines, mobilizes cells in the immune system, such as S-IgA; it is associated with cognitive function, such as attention, memory, learning, and emotional regulation (Levine, Zagoory-Sharon, Feldman, Lewis, & Weller, 2007; McEwen, 2005, 2006, 2008; Miller, et al., 2007; Nicolson, 2007; Soares & Alves, 2006). Increases in cortisol levels enhance cortical-subcortical cross talk associated with inhibited behavior and anxious, non-risky decision-making (Schutter & van Honk, 2005). Although cortisol is a marker of HPA axis function, dysregulation at higher levels of this system are not always translated into observable changes in momentary cortisol levels and vice-versa.

The Assessment of Cortisol

Cortisol is extensively researched because of its association with the adaptive response to stress, its role in other physiological systems, and the ease of ambulatory assessment. The associations between momentary stress, daily hassles, and affect have been widely investigated in natural and laboratory settings (Adam, 2006; Jacobs, et al., 2007; Nicolson, deVries, Sulon, & Vonpoll, 1988; Ockenfels, et al., 1995; Polk, et al., 2005; Smyth, et al., 1998; van Eck, Berkhof, Nicolson, & Sulon, 1996; van Eck &

Nicolson, 1994; van Eck, Nicolson, Berkhof, & Sulon, 1996). In particular, cortisol is sensitive to novel, uncontrollable stimuli, and social stressors (Dickerson & Kemeny, 2004; Dickerson, Mycek, & Zaldivar, 2008).

The ambulatory assessment of cortisol using saliva samples is a valuable resource to understand the circadian rhythm and momentary responses to daily contexts in natural settings. Salivary cortisol is highly correlated with free cortisol levels in the blood stream, thus representing a good indicator of cortisol levels and the neuroendocrine response of the organism to stimuli (Levine, et al., 2007; Nicolson, 2007). Using saliva to sample cortisol is less intrusive and demanding than gathering blood and urine samples. Salivary cortisol is stable at room temperature for several weeks, at 5º C for three months, and can be kept frozen for a year (Clements & Parker, 1998; Garde & Hansen, 2005; Kirschbaum & Hellhammer, 2000; Levine, et al., 2007; Nicolson, 2007). Its sampling is easily taught to participants, which is important in experience sampling studies: participants collect saliva samples as they go about their daily lives without much hassle and they can store samples at home in the freezer or refrigerators until the end of the assessment period.

Finally, the assessment of cortisol takes into account its circadian pattern, the momentary response to stimuli, and their interdependence. The assessment of cortisol secretion is based on four dimensions that represent both inter-individual and intraindividual variations and patterns: the cortisol awakening response (CAR); the circadian pattern and diurnal rhythm; the basal cortisol level; and the momentary cortisol response to and recovery from demanding contexts in natural and laboratory settings.

The cortisol awakening response (CAR).

Cortisol levels rise steeply (50%-160%) in the first 30-50 minutes after waking, starting to decline 60 minutes afterward. Cortisol plays an important role in the daily wake-sleep pattern and in the allocation of energetic resources in preparation for the coming day. Laboratory studies showed that the CAR occurs only in the morning and not if subjects awaken during the night or after an afternoon nap (Dettenborn,

Rosenloecher, & Kirschbaum, 2007; Federenko, et al., 2004; Wilhelm, Born, Kudielka, Schlotz, & Wust, 2007). The CAR is sensitive to environmental conditions, such as time of waking and exposure to light. Earlier waking hours and greater light exposure after waking are associated with a greater CAR, compared to waking up late and low exposure to light (Clow, Hucklebridge, Stalder, Evans, & Thorn, 2009; Kudielka & Kirschbaum, 2003; Thorn, Hucklebridge, Esgate, Evans, & Clow, 2004; Williams, Magid, & Steptoe, 2005).

The CAR shows good intraindividual stability and some studies have shown that its pattern is associated with heritable characteristics of the HPA axis function, age, gender, and hormonal function in women (Almeida, Piazza, & Stawski, 2009; Chida & Steptoe, 2009; Hewig, et al., 2008; Kupper, et al., 2005; Weekes, et al., 2008; Wolfram, Bellingrath, & Kudielka, 2011; Wust, Federenko, Hellhammer, & Kirschbaum, 2000). However, adaptation to environmental conditions can lead to changes in the CAR pattern (Liberzon, Abelson, King, & Liberzon, 2008). For example, burnout, adverse life experiences, post-traumatic stress disorder, and chronic depression have been associated with a blunted CAR (Chida & Steptoe, 2009; Fries, Dettenborn, & Kirschbaum, 2009; Gonzales, Jenkins, Steiner, & Fleming, 2009; Huber, Issa, Schik, & Wolf, 2006; Pruessner, Hellhammer, & Kirschbaum, 1999; Schlotz, Hellhammer, Schulz, & Stone, 2004; Stetler & Miller, 2005; Wessa, Rohleder, Kirschbaum, & Flor, 2006); while chronic job stress and general life stress are associated with greater CAR (Chida & Steptoe, 2009; Maina, Bovenzi, Palmas, & Larese Filon, 2009; Schulz, Kirschbaum, Prussner, & Hellhammer, 1998; van Santen, et al., 2011; Wust, et al., 2000). Greater CAR in adolescence has been associated with a greater risk of development of major depressive disorder in adulthood (Adam, et al., 2010). Trait characteristics, such as trait anxiety, loneliness, neuroticism, and type-D personality are associated with greater CAR, whereas optimism, self-esteem, positive affectivity, and seasonality are associated with lower CAR (Cacioppo, et al., 2000; Greaves-Lord, et al., 2007; Lai, et al., 2005; Polk, et al., 2005; Portella, Harmer, Flint, Cowen, & Goodwin, 2005; Pruessner, et al., 2005; Steptoe, et al., 2007; Steptoe, et al., 2004; Thorn, Hucklebridge, Evans, & Clow, 2009; Whitehead, Perkins-Porras, Strike, Magid, & Steptoe, 2007). Although there is a tendency for positive traits to be associated with overall lower CAR levels, there is some evidence that higher CAR is

associated with higher socio-economic status, assertiveness, and ability to cope with novelty and change (Seeman & McEwen, 1996).

The CAR is also sensitive to state components: individuals experience higher CAR on work vs. non-work days, on days in which arousal, stress and anxiety are high, and when during the previous day individuals felt lonely, less happy, and anticipated arousing situations in the upcoming day (Dahlgren, Kecklund, Theorell, & Akerstedt, 2009; Fries, et al., 2009; Hellhammer, et al., 2007; Kunz-Ebrecht, Kirschbaum, Marmot, & Steptoe, 2004; Stalder, Evans, Hucklebridge, & Clow, 2010; Steptoe, et al., 2004; Thorn, et al., 2009; Weekes, et al., 2008; Zoccola, Dickerson, & Yim, 2010). Therefore, researchers should take into consideration state and trait components that interact and modulate the CAR.

Basal cortisol and daily rhythm.

Basal cortisol levels are indicative of the overall activation of the HPA axis. Hyper- and hypoactivation of the HPA axis can lead to physical and psychological pathology. In daily life studies, researchers aggregate the values of several saliva samples throughout the day to estimate the total daily cortisol output and other researchers determine overall cortisol output based on the area under the curve. Basal cortisol levels are influenced by age, gender, and hormonal changes (Nicolson, Storms, Ponds, & Sulon, 1997; Seeman & McEwen, 1996; Seeman, et al., 1995): for example, young men show higher basal cortisol compared to young women; however, in old age this pattern is reversed.

High basal cortisol levels have been associated with anxiety, social isolation, loneliness, coping styles, and cognitive impairment in the elderly, especially women (Cacioppo, et al., 2000; House, et al., 1988; Kiecolt-Glaser, et al., 1984; Mantella, et al., 2008; O'Donnell, et al., 2008); lower basal cortisol is associated with positive affectivity, psychological well-being, engaging in a variety of leisure activities, physical exercise, and positive relations; however, it is also associated with vital exhaustion, chronic depression and chronic fatigue (Adam, 2006; Hansen, et al., 2010; Harte, et al., 1995; Nicolson & van Diest, 2000; Pressman, et al., 2009; Ryff & Singer,

2002; Steptoe, O'Donnell, Badrick, Kumari, & Marmot, 2008; Steptoe & Wardle, 2005).

Self-esteem and hardiness have been associated with greater basal cortisol (Zorrilla, DeRubeis, & Redei, 1995) and higher hippocampal volume and lower stress reactivity in a different study with young and old men (Pruessner, et al., 2005). This apparently contradictory finding is also observed in the association between higher basal cortisol levels and greater mastery levels in women (Ryff & Singer, 2002). A possible explanation is that by drawing comparisons from samples of only healthy participants, individuals who are more active throughout the day may exhibit higher cortisol levels than less active individuals. Also, the lower levels associated with positive psychological resources might only be lower in comparison to a healthy sample, although higher in comparison to participants with psychopathological disorders. However, we can only understand whether these high or low cortisol levels are comparable to those present in symptomatic individuals with studies comparing healthy and symptomatic participants.

An aggregate measure of basal cortisol has limited capacity to represent the diurnal patterns and rhythms of cortisol. Therefore, researchers have used estimates of individual slopes to assess the diurnal rhythm of cortisol. Individual slopes are sensitive to variations in cortisol levels throughout the day. Flatter cortisol slopes have been associated with adverse early life experiences, chronic stress, and a variety of psychological and physical pathology, as well as daily feelings of tension and anger (Adam, 2006; Gunnar & Vazquez, 2001; van der Vegt, van der Ende, Kirschbaum, Verhulst, & Tiemeier, 2009). Steeper slopes seem to indicate a better overall functioning and positive relationship function (Adam & Gunnar, 2001; Polk, et al., 2005).

Momentary cortisol levels.

Finally, the momentary cortisol response to stimuli offers important information about the HPA axis activity and reactivity to daily life. Cortisol response is associated with psychosocial stress, novelty and perceived uncontrollability. Cortisol influences

performance, affect, and executive function processes. The effects of stress, challenges, and the increases of cortisol are sometimes contradictory and seem to be related to age and gender (Wolf, Convit, et al., 2001; Wolf, Schommer, et al., 2001). For example, higher cortisol levels in young adults impair short-term memory, improve selective and divided attention, memory and recall for emotionally (positive and negative) charged words and context-related information; also, men seem to have higher cortisol responsiveness to stress than women (Joels, Pu, Wiegert, Oitzl, & Krugers, 2006; Schwabe, et al., 2008; Smeets, Wolf, et al., 2009; Vedhara, Hyde, Gilchrist, Tytherleigh, & Plummer, 2000). However, increased cortisol responsiveness in the elderly is associated with overall decreases in memory and attention processes, especially in women (Seeman, McEwen, Singer, Albert, & Rowe, 1997). According to Lupien and McEwen (1997), the effects of cortisol on cognitive function and performance have a U-shape, in which very low and high levels of cortisol are conducive to impaired cognitive function, whereas moderate cortisol levels improve memory and attention. Joels and colleagues (2006) propose that increased cortisol levels can have positive effects on memory and learning. The authors propose that levels of cortisol and timing of arousal are important components to understand the effects of cortisol on cognition: cortisol increases adjacent to learning enhance it, whereas cortisol increases 15 minutes or more before the learning task can impair learning.

In daily life studies, researchers integrate physiological and psychosocial dimensions in experience sampling procedures. Whenever participants hear the signal, they collect saliva samples and fill in a questionnaire. In studies of daily life, greater momentary cortisol levels are associated with daily hassles, experiences of stress, negative affect and daily solitude (Adam, 2006; Gunnar & Donzella, 2002; Jacobs, et al., 2007; Matias, et al., 2011; Nicolson, et al., 1988; Polk, et al., 2005; Smyth, et al., 1998; van Eck, et al., 1996; van Eck & Nicolson, 1994). Lower momentary cortisol levels are associated with positive affect, happiness and productivity (Adam, 2005; Matias, et al., 2011; Polk, et al., 2005; Smyth, et al., 1998). In the current study we investigated the associations between state and trait characteristics related to the flow model and different dimensions of cortisol secretion.

The Psychophysiology of Flow

The implications of the flow state in the development, learning, and individual and cultural growth have been widely studied for more than 30 years. However, there is still little knowledge about the associations between the flow state, the autotelic personality and physiological and neurological functions. Csikszentmihalyi (1993, 1997a; Csikszentmihalyi & Csikszentmihalyi, 1988) proposed that the flow state is a mental and physical state of high arousal with a positive emotional tonus. The physical and mental activation might explain the absence of physical signs (e.g., lack of hunger and thirst) and the reduction of somatic complaints (e.g., headaches and back pain) reported in flow experiences. In *The Evolving Self,* Csikszentmihalyi (1993) hypothesized that physiological and neurological (e.g., increases in serotonin) processes may facilitate the emergence, maintenance, and repetition of the flow state.

As discussed earlier, different studies used a wide range of methodologies (e.g., momentary assessment vs. retrospective assessment) and operationalizations of the flow state (e.g., balance challenges-skills, indexes of dimensions related to flow). Theoretical and empirical studies about the associations between flow, flow components, and neurophysiological function have also used discrepant measures. While some focus on attentional processes and executive function (Dietrich, 2003, 2004; Dietrich & Stoll, 2011), others use indices based on all components of flow (de Manzano, 2010; de Manzano, Theorell, Harmat, & Ullen, 2010; Kivikangas, 2006; Ullén, de Manzano, Theorell, & Harmat, 2011), or on independent components of the flow experience (de Manzano, 2010; de Manzano, et al., 2010; Ullén, et al., 2011). In the interest of structuring earlier research and theories about the psychophysiology of flow, we will review the research on neurological correlates of the flow state. Next, we will describe the associations found between flow and physiological markers in laboratory settings. Finally, we will explore the associations between flow constructs, flow dimensions, and cortisol, in laboratory and naturalistic settings.

Dietrich (Dietrich, 2004; Dietrich & Stoll, 2011) proposes that the flow state emerges from the synergetic activity between the explicit and implicit systems. The

explicit system is responsible for the integration of information of cognitive and emotional systems, cognitive flexibility, the activation of top-down control in conflicting situations, monitoring performance, self-representation processes (e.g., emotional introspection and self-judgment), and the intentional direction of attention and deployment of effort in the task. The implicit system is associated with automatic processing of information that does not require effort in the allocation of attention and complex patterns that require automation; it is associated with procedural memory, fast and accurate responses to environmental stimuli, and sensorimotor processing. Explicit processing activates the dorsolateral and medial prefrontal cortex, the anterior cingulate cortex, hippocampus, and temporal lobe structures, whereas implicit processing activates the limbic system and basal ganglia (Blais, 2011; Dietrich, 2004; Dietrich & Stoll, 2011; Goldberg, Harel, & Malach, 2006; McGuire & Botvinick, 2011). The activation of structures associated with the implicit and explicit processing is antagonic; therefore, the activation of the implicit system in the experience of flow is characterized by a transient state of hypofrontality that inhibits the explicit system until this is needed. This transient state results in the perception of loss of self-consciousness, awareness about surroundings, and effortless attention reported in flow states, in particular, in sensorimotor processing and superior performance (Dietrich & Stoll, 2011; Goldberg, et al., 2006).

Other studies have focused on the physiological differences between perceived effortless and effortful attention. Perceived effort is expected to arise as a result of external (e.g., perceived demands) and internal conditions (e.g., motivation, perceived reward) (McGuire & Botvinick, 2011). However, there are energetic differences in terms of perceived effort invested and blood glucose levels: while effortful attention is followed by glucose depletion, effortless attention is not associated with changes in glucose levels, regardless of the levels of perceived challenges and involvement in the task (Schmeichel & Baumeister, 2011).

In laboratory settings, the psychophysiology of flow has been studied in expert piano players (de Manzano, 2010; de Manzano, et al., 2010; Ullén, et al., 2011) and in young adults playing video games (Keller, Bless, Blomann, & Kleinbohl, 2011; Kivikangas, 2006).

The flow experience in pianists was assessed with the FSS and with an index based on the average of ratings of perceived attention, balance between challenges and skills, and autotelicity. Greater flow scores were associated with increased activity of the *zygomaticus major* muscle (indicator of positive affect) and respiratory depth, and decreased heart rate variability and respiratory *sinus arrhythmia* (de Manzano, 2010; de Manzano, et al., 2010; Ullén, et al., 2011). The authors propose that the co-activation of the sympathetic nervous system and the parasympathetic modulation of sympathetic activity, associated with processes of effortless attention and flow, precede optimal coping and account for the high performance associated with the flow state.

The study of flow in video games shows contrasting results. In the study of young men, greater flow scores were associated with decreased activity of the *corrugator supercilii* muscle (indicator of negative affect), but not with activity of the *zygomaticus major* muscle and skin conductance, a measure of physiological arousal (Kivikangas, 2006). In an exploratory study with women, flow was associated with decreased heart rate variability, compared to experiences of boredom and overload (Keller et al., 2011). Next, we look at research about links between neuroendocrine function, the flow state, and flow-related constructs.

The Flow State, Flow Components, and Cortisol

Earlier studies about the neuroendocrine association with challenging contexts showed that *effort without distress* was associated with reduced reactivity of cortisol in a laboratory task, compared to situations of *effort with distress* (Frankenhauser & Lundberg, 1982; Lundberg & Frankenhaeuser, 1980). Effort without distress is a flow-related construct in which effort is allocated to confront manageable challenges, in which participants experience control, motivation, and concentration; effort with distress resembles the channel of anxiety (EFM) in which challenges are perceived as uncontrollable and participants experience lower motivation and concentration, and higher distress.

The findings about the role of cortisol on attention processes are contradictory, especially if we look at attention and memory processes involved in the flow state. The

flow state is characterized by focused and sustained attention, and disregard of task-unrelated stimuli. An adequate amount of stress contributes to increase selective attention to attend to task-related stimuli, while disregarding task-unrelated stimuli (Chajut & Algom, 2003). The selective attention process seems to benefit from increased cortisol levels in young adults and increased cortisol levels were associated with better performance in executive tasks in children. Finally, greater cortisol is associated with learning of emotional-laden content, especially of negative tonus. However, being under stress was also associated with better memory and recall of neutral words, compared to not being stressed at the moment of the learning task. The ease, creativity and performance linked to the flow experience depends on cognitive flexibility and working memory processes that enable integration of current and past information in a flexible and creative way, but increases in cortisol were associated with impaired working memory in young adults.

In a study with male college students, challenges and skills were manipulated to induce situations of balance and imbalance. Being in a flow state (challenges match skills) was associated with higher cortisol, compared to the boredom state (challenges lower than skills). However, cortisol levels were similar in states of flow and overload (challenges surpass skills) (Keller, et al., 2011). Further analyses showed that, although being in flow was associated with higher involvement than being in boredom and overload, there were no significant differences in affect between these manipulations. These findings draw comparisons with the research on cortisol and workload.

Gender differences in the cortisol response can also be responsible for the discrepant findings among men and women (Kirschbaum, Wust, & Hellhammer, 1992; Kudielka & Kirschbaum, 2005; Seeman, et al., 1995). Kajantie and Phillips (2006) found that the cortisol response to laboratory challenges is greater in men than in women. Also, different laboratory challenges elicit gender-specific cortisol responses: men exhibit greater cortisol in response to achievement-related challenges, whereas women are more sensitive to social-related challenges (Stroud, Salovey, & Epel, 2002). Furthermore, cortisol influences executive performance differently according to gender: men exhibit improved cognitive flexibility and executive function performance with heightened cortisol, whereas women show the opposite pattern (McCormick, Lewis, Somley, & Kahan, 2007).

In daily life studies, women who reported feeling productive had lower cortisol than those who reported not feeling productive at that moment (Adam, 2005). Feeling productive was also associated with increased positive affect and decreased negative affect. Increases in positive affect and decreases in negative affect are associated with the flow state (Csikszentmihalyi, 1997a, 1997b, 2002; Csikszentmihalyi & Rathunde, 1992; Freire & Matias, 2008; Nakamura & Csikszentmihalyi, 2002; Rogatko, 2009) and momentary cortisol response (Adam, 2005, 2006; Doane & Adam, 2010; Jacobs, et al., 2007; Matias, et al., 2011; Polk, et al., 2005; Steptoe, et al., 2009; Steptoe, et al., 2007; van Eck, et al., 1996; van Eck & Nicolson, 1994). Therefore, it seems that the affective experience of flow would translate into decreased levels of cortisol in women's daily life. However, feeling productive might not always be associated with intense engagement. Individuals can feel productive in activities that are going well, even if they don't demand full physical and mental activation.

The Autotelic Personality and Cortisol

The flow model proposes that autotelic individuals may possess physiological, attentional and psychological advantages that predispose them to look for and experience higher engagement in daily life (Csikszentmihalyi, 1993, 1997a, 2002; Nakamura & Csikszentmihalyi, 2002). Research has shown that personal characteristics are associated with cortisol responses in daily contexts and laboratory challenges, distinct cortisol daily rhythm, basal levels and cortisol awakening response. Therefore, autotelic individuals may present characteristic psychoneuroendocrinological patterns that explain their propensity to be highly engaged. To our knowledge, no previous research has focused on the associations between the autotelic personality and physiological function in daily life. However, several personal characteristics associated with the autotelic personality have been associated with cortisol secretion and patterns.

There is evidence that lower cortisol levels reflect a healthier, more adaptive neuroendocrine function (Lindfors & Lundberg, 2002). Adaptive lower cortisol levels differ from pathological levels of hypocortisolism, because they are within the limits of normative cortisol levels and are not associated with symptoms of hypocortisolism

(e.g., fatigue, compromised immune system). Also, unlike an absent or over reactive cortisol response, which is associated with some psychopathological states, lower levels associated with positive function present an adequate cortisol response when confronted with adverse and demanding stimuli (Peeters, Nicholson, & Berkhof, 2003; Peeters, Nicolson, & Berkhof, 2004).

The autotelic personality has been linked to other positive personal characteristics and low levels of negative personal characteristics, which have been associated with cortisol secretion. Positive personal characteristics, such as happiness, psychological well-being, positive affectivity, optimism, adaptive coping, and secure attachment are associated with lower levels of basal cortisol, cortisol awakening response, and momentary cortisol responses to daily contexts and laboratory challenges (Adam & Gunnar, 2001; Bohnen, et al., 1991; Bostock, et al., 2011; Lai, et al., 2005; Matias, et al., 2011; O'Donnell, et al., 2008; Polk, et al., 2005; Pruessner, et al., 2005; Ryff & Singer, 2002; Steptoe, et al., 2009; Tsuda, et al., 2008). Also, low levels in trait anxiety, neuroticism, depression, loneliness, and negative affectivity are associated with lower cortisol in its various dimensions (Adam, et al., 2010; Adam, Hawkley, Kudielka, & Cacioppo, 2006; Doane & Adam, 2010; Fries, et al., 2009; Grant, Hamer, & Steptoe, 2009; Hauner, et al., 2008; Hawkley & Cacioppo, 2003b; Kiecolt-Glaser, et al., 1984; Matias, et al., 2011; Peeters, et al., 2003; Polk, et al., 2005; Portella, et al., 2005; Steptoe, et al., 2004; Thorn, et al., 2009; van Eck, et al., 1996; van Santen, et al., 2011). We infer from these previous associations that autotelic individuals will show lower cortisol levels at waking, CAR, and momentary cortisol in response to daily experience and contexts than less autotelic individuals.

Aims

The aim of the current research project was to investigate the associations between daily experiences and contexts, personal characteristics and neuroendocrine function. We focused on the flow state, an autotelic experience characterized by intense involvement, with short- and long-term beneficial psychological effects and which influences personal and societal development.

Our first aim was to understand whether engagement in daily life is associated with a more positive affective, cognitive, and motivational experience, overall, and within specific daily contexts. We investigated whether engagement could ameliorate the effects of solitude on subjective experience and whether it could enhance the motivational, cognitive and affective experience in study activities, thus increasing the likelihood of students participating in study activities more often. Finally, we examined whether subjective experience and solitude were associated with cortisol secretion.

Our second aim was to investigate whether personal characteristics were associated with differences in momentary subjective experience and neuroendocrine function in daily contexts. We focused on the individual propensity to experience engagement in daily life (the autotelic personality) and on levels of positive and negative affectivity. We investigated whether students with high autotelic personality, high levels of positive affectivity, and low negative affectivity had a better subjective experience, overall and in specific daily contexts (study and solitude). Finally, we investigated whether levels of autotelic personality, positive affectivity and negative affectivity were associated with individual differences in cortisol secretion.

Part II: Empirical Research

Chapter 3: Method

Participant Characteristics

Female college students from the University of Minho, Portugal, took part in this research project in either December 2007 - March 2008, December 2008 – March 2009, or October 2009 - January 2010. The study was presented in the classroom and volunteers were later contacted to schedule an interview. During this interview, we explained the procedures in detail, emphasizing the importance of compliance. Of approximately 150 volunteers, 78 agreed to participate in the study after the interview. Of these, four were excluded due to use of corticosteroids, two due to hormone imbalance, one due to non-compliance with the study's protocol, and four due to technical problems during the assessment week. None of the participants had a history of mood or anxiety disorders, as ascertained by interview. All participants gave written informed consent. After study completion, participants received a 2.5€ voucher for office supplies or class credit, if enrolled in an eligible class.

Participants were undergraduates in the first (63.1%), second (29.2%), or third (7.7%) year of college. Half of them (50.1%) were living at home, whereas the other half had moved from the parents' home to attend college. Mean age was 20 years (SD = 1.9), mean body mass index (BMI) was 22.3 (SD = 2.9), and mean hip-waist ratio was 0.8 (SD = 1.0). Of this all-female sample, 42 out of 67 reported using oral contraceptives, 7 reported smoking tobacco, and 20 reported drinking alcohol at least once a month.

As shown in figures 5 and 6, during the assessment week participants spent most of their time in activities (Figure 6) related to study (e.g., attending a class, studying for a test) and maintenance (e.g., eating, doing household chores), followed by social interactions (e.g., talking to friends) and leisure (e.g., reading a book, dancing). In terms of the company they were with (Figure 5), participants spent most of their time alone, followed by time with their colleagues and teachers, and their family. In part,

these time budget descriptions reflect the reality of most of our sample, which spend most of their time in college with colleagues in study activities.

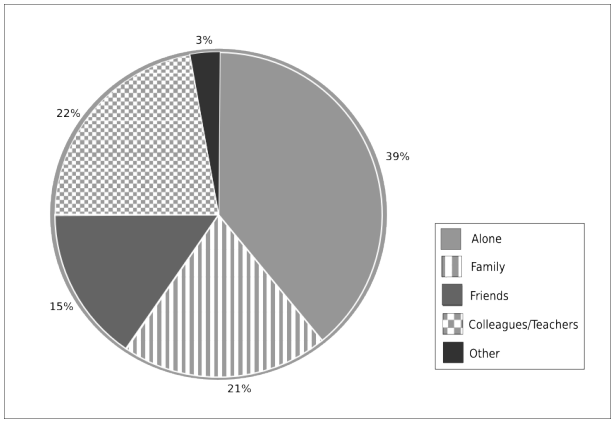

Figure 5 - Time spent with different company during the assessment week.
Note. "Time spent with company" is obtained by the percentage of valid ESF in each company category, *per* participant.

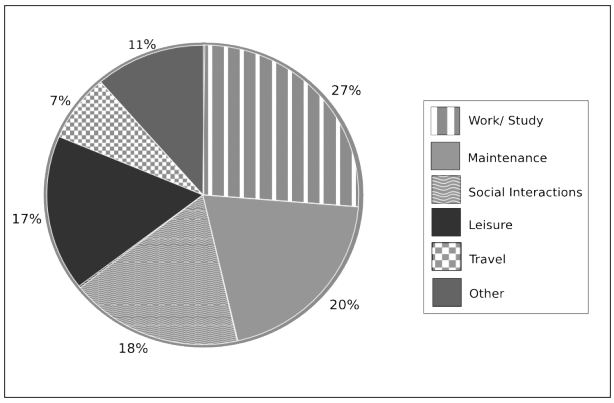

Figure 6 - Time spent in different activities during the assessment week.
Note. "Time spent in activities" is obtained by the percentage of valid ESF in each activity category, *per* participant.

Compliance.

Participants provided a total of 2270 ESM reports (70.6% of maximum possible), coupled with 1693 saliva samples. Of all the answered ESM reports, 8.1% were considered invalid because they were completed >20 minutes after the beep. On average, each participant completed 32 ESM reports (range 18-41) and 25 saliva samples (range 12-42).

Measures

The Experience Sampling Method (Csikszentmihalyi & Larson, 1987; Hektner, et al., 2007)

We used the ESM to analyze the everyday experiential and contextual experience of female college students. The ESM methodology assesses affective, motivational and cognitive components of experiences, activities, physical and social contexts in which individuals engage as they go about their everyday lives. Participants carried a booklet with ESM questionnaires (*Experience Sampling Forms – ESF – see Appendix A1*) and an electronic pager (*see Appendix A2* – Machado, Gomes & Freire, 2009) for 6 days. The pager was programmed to emit 8 beeps at random moments each day, from 8:00 until 23:00. After each beep, participants completed 11 open questions and 32 ratings (Likert type scales ranging from 0 not at all, to 12 extremely) concerning thoughts ("*What are you thinking about?*"), context ("*What are you doing?"; "Who are you with?"; "Where are you?*"), fatigue ("*I feel…*" *active, tired, sleepy*), and affective (e.g., "*I feel…" happy, sad, lonely, joyful*), cognitive (e.g., "*How concentrated are you?"; "How hard is it for you to concentrate?"; "How much do you feel in control?"; "Are you thinking about yourself?*"), and motivational components of experience (e.g., "*Would you rather be doing something else?"; Would you rather be with someone else?"; "Would you rather be somewhere else?*"). Each report took approximately 1-2 minutes to complete. Compliance to protocol was evaluated based on the recommendations to reduce possible cognitive bias outlined by Hektner and colleagues (2007) and Csikszentmihalyi and Larson (1987): filling the ESF in less than 20 minutes after hearing the beep and having at least 15 valid ESM reports per participant.

Salivary Cortisol Sampling

In the current research project participants collected saliva samples at the same time they completed ESM reports. In addition, on two consecutive weekdays, they collected two extra saliva samples: at wake time and 30-40 minutes after awakening.

Saliva samples were collected using Salivettes® (Appendix A3), small plastic tubes containing cotton dental rolls. Participants chew lightly on the cotton until it is saturated with saliva and store it in the tube. At the end of each day participants stored the samples in their home refrigerators. They returned the samples to the laboratory twice during the assessment week. Saliva samples were centrifuged at 3500rpm for 10 minutes and were stored at -20º in the laboratory until analysis. A duplicate radioimmunoassay was performed according to kit instructions (Orion Laboratories) in the laboratory *Clínica Dr. Egas Botelho Moniz*, Santo Tirso, Portugal. The lower detection limit of the assay was 1 nmol/L, with a mean intra-assay coefficient of variation below 6%. To avoid effects of potential confounders on cortisol, participants recorded the time of awakening, food intake, alcohol consumption, and medication use in their booklets. Other variables, such as contraceptive and tobacco use were assessed through interview.

Cortisol awakening response (CAR) procedure.

The response of cortisol to awakening is time sensitive, and non-compliance with sampling times is known to bias results. Researchers recommend electronic monitoring of the time of sample collection (Broderick, Arnold, Kudielka, & Kirschbaum, 2004; Kudielka, Broderick, & Kirschbaum, 2003; Kudielka, Hawkley, Adam, & Cacioppo, 2007). However, electronic monitoring of collection times was not possible in this research project due to budgetary constraints. To increase compliance, we explained to participants the adverse effects of non-compliance on results during the initial interview, as done in previous studies on CAR without electronic monitoring (Thorn, et al., 2009).

We suggested leaving salivette tubes on the nightstand before going to sleep, so participants would remember to collect the morning samples. Also, we asked participants to provide the samples during two consecutive workdays. Previous research had shown that individuals are often non-compliant in protocols to assess the CAR, which can bias analyses results. Hence, to reduce bias effects from non-compliance we included only individuals that provided valid saliva samples for 2 consecutive weekdays. We considered the samples valid if they were gathered between

30-50 minutes after reported waking hour and if there was no decline between the sample after awakening and the second sample.

Variables

The variables used in the current research project were developed based on the items present in the ES forms. The items used assessed momentary experience, daily contexts and person-level characteristics.

We developed momentary variables based on either scales that have shown high reliability and consistency, or psychological constructs of interest. For example, the affect scales were based on items already associated with positive and negative affect in other studies and scales, such as the PANAS (Crawford & Henry, 2004; Watson, Clark, & Tellegen, 1988), and that were associated with each other, as estimated through factor analysis. Other variables' development followed the rationale of psychological constructs. For example, effortless attention and engagement were operationalized in a way that reflects particular experiences of interest to the current research project. Being highly focused in a task doesn't ensure that participants felt it was easy to concentrate. In other cases, participants may have felt that concentration came easily and yet, they were not focused on the task. Assessing a situation in which participants were highly concentrated and felt it was easy to concentrate gives us a measure of the construct of effortless attention (Csikszentmihalyi & Nakamura, 2011).

Daily contexts of interest were based on the answers to open-ended questions related to participants' company and activity at the moment of each beep. Finally, person-level characteristics are based on aggregated measures during the assessment week. These variables reflected the individual propensity to experience positive affect and negative affect, as well as high levels of engagement in daily life. Although we sampled only one week, other studies have shown that some personality characteristics, such as affectivity, are stable when assessed in different weeks. Autotelic personality characteristics were assessed based on an overall measure that reflects an internal cognitive-affective-motivational individual functioning.

Momentary Subjective Experience

Affect: A principal component analysis with Varimax rotation was conducted on within-individual z-scores calculated for ten ESM affective items. The analysis identified two major factors, which together explained 54.45% of the intraindividual variance in affective states. Four items ("*I feel…*" *happy, cheerful, joyful,* and *in a good mood*) loaded heavily on the first factor and formed the *Positive Affect* (PA) scale, which explained 31.9% of intraindividual variance. Six items ("I feel…" *angry, sad, anxious, bored, lonely, and apathetic*) loaded heavily on the second factor, forming the *Negative Affect* (NA) scale, which explained 22.6% of total variance. Both scales showed good reliability (Cronbach's $\alpha = .89$ for PA, and Cronbach's $\alpha = .72$ for NA). The scales could range from 0 - not at all - to 12 - extremely.

Effortless Attention: effortless attention was based on the items "*Were you very concentrated*?" and "*How hard was it for you to concentrate?*" We reversed the scores of the latter response scale. The scores on effortless attention were based on the square-rooted product of the interaction between the two items. We used the square-rooted score so that the final scores are similar to those used in the Likert response scales in the ESM reports (0 *not at all* to 12 *extremely*). Therefore, a higher score represents situations in which the individual is highly concentrated and feels that it is easy for him to concentrate, as opposed to lower scores, which represent situations in which there is low concentration and it is hard to concentrate.

Motivation: motivation was assessed using the reverse score of the item "*Would you rather be doing something else?*" The item ranges from 0 - *not at all* - to 12 - *extremely*. Higher scores reflect greater satisfaction and willingness to be in the current activity, and lower scores represent desire to be doing something else.

Fatigue: fatigue was assessed based on the averaged scores for the items *tired, sleepy,* and *active*. The scores for the item *active* were reversed. The scale ranged from 0 - *not at all* - to 12 - *extremely* -, with higher scores representing feeling more tired and sleepy, and lower scores representing feeling more active and energetic. The scale showed good reliability (Cronbach's $\alpha = .64$).

Importance of the activity: This scale assesses the perceived importance of the activity for the individual's immediate and future goals based on the average score of two ESM items ("*Was there something important in the activity you were doing?"* and *"Was the activity important to any of your life goals?*"). The scale's score ranges from 0 - *not at all* - to 12 - *extremely*. Higher scores reflect the perception of greater importance and goals within an activity, whereas low scores represent activities that are unimportant for present and future goals. The scale showed good reliability (Cronbach's $\alpha = .72$).

Perceived control: The momentary perception of control in the current activity was based on the score in the ESM question, "*Did you feel in control?*" The scale scores ranges from 0 - *not at all* - to 12 - *extremely*, with higher scores representing greater control over the activity.

Creativity: Creativity was based on the score in the ESM item "*I feel… creative*". The item ranges from 0 - *not at all* - to 12 - *extremely*. Higher scores indicate the individual perception of being extremely creative in the moment of assessment.

Self-consciousness: Self-consciousness was based on the response to the question, "*Were you thinking about yourself?*" The scale scores range from 0 - *not at all* - to 12 - *extremely*. Greater scores reflect more self-consciousness, whereas lower scores reflect loss of self-consciousness.

Optimal experience/ flow.

Several variables were developed to investigate the associations of flow with the internal and external dimensions of everyday experience. These variables reflect low to high intensities of optimal experiences. Although the optimal experience has been associated with positive affect, we purposefully chose not to include this variable in the creation of flow measures. According to the flow theory, optimal experiences emerge in situations in which emotions, goals and thoughts are in harmony (Csikszentmihalyi, 1997a). Although positive affect may be higher than average, it should not be so intense that it might disturb the engagement in the activity. Therefore, although high levels of challenges, skills, effortless attention and motivation must exist

in an optimal experience, including positive affect in the same scale could bias the scale's intensity levels.

Balance levels (BL): balance levels were determined based on the product of ratings in the items "*Was the activity in which you were participating challenging and an opportunity for action and expression?"* and *"Considering your skills, were you able to match the situation's [demands]?"* The raw values were square-rooted to express values similar to the original items' Likert scales (0 - 12). The interaction term of challenges and skills has been used elsewhere as a way to assess the intensity of the experience (Schmidt, et al., 2007). Higher values (12) represent experiences in which individuals perceive high levels of challenges and skills, whereas lower values (0) represent experiences in which students perceived low challenges and skills.

Autotelicity levels (AL): autotelicity levels were based on the square-rooted product of the interaction of the raw scores on *motivation* and *effortless attention*. Higher scores (12) reflect high levels of effortless attention and motivation when in the activity, while low scores represent activities in which individuals have scattered attention, difficulty to concentrate, and wish to be doing something else.

Engagement levels (EL): levels of engagement were based on the square-rooted product of the interaction between the momentary scores on BL and AL. The aim of this variable was to assess the flow state, in which the main internal and external conditions for the optimal experience are met.

Daily Contexts

We studied two of the most prevalent contexts in daily life: *company* and *activities*. We chose to analyze study activities and solitude against all other daily activities and company, respectively. Solitude and study activities represent a great part of college students' daily lives, fundamental to their development. These contexts also represent optimal opportunities to observe whether being in a flow state can help create a positive affective, motivational and cognitive experience from a potentially negative experience.

Daily company.

At the moment of each beep, participants listed the company they were with in response to the open question, "*Who are you with?*" This information was later coded into different categories according to *company* (alone, family, friends, colleagues, and others). Categories used in this research were based on previous qualitative analysis performed by our research group of answers given by adolescents and adults to this ESM question (Freire, 2011). In the current research, for descriptive reasons, we have used the main categories alone, family, friends, and others. We did not evaluate the time spent with colleagues as it was associated mainly with time spent studying, both during class and outside of it, and we did not want the experience of study to bias experiences associated with company. We performed an interrater reliability analysis on 100 reports, coded by two raters. The Kappa statistic determined that consistency between the two raters was high (Kappa = .98, $p < .001$).

Solitude: Responses were collapsed into the categories *alone* and *not alone*. Contexts in which participants reported being physically alone (e.g., *alone, alone in my room*) were dummy coded as *alone* (1), whereas those in which other people were present (e.g., *alone in a crowd, with friends, with colleagues*) were coded as *not alone* (0).

Daily activities.

At the moment of the beep, participants listed the main activity they were currently involved in, in response to the open question "*What are you doing?"* This information was later coded into different categories according to *activity* (nothing, study, leisure, maintenance activities, travel, others). Categories used in this research were based on previous qualitative analysis performed by our research group of answers given by adolescents and adults to this ESM question (Freire, 2011). We performed an interrater reliability analysis on 100 reports, coded by two raters. The Kappa statistic determined that consistency between the two raters was high (Kappa = .80, $p < .001$).

Study: Responses were collapsed into the categories *study* and *not study*. Contexts in which participants reported being in a study activity (e.g., studying, listening to class, doing homework) were dummy coded as *study* (1), whereas those in which they were doing something else (e.g., watching TV, listening to music, eating, driving) were coded as *not study* (0).

Personal Characteristics

Affectivity: The scores for each of the momentary ESM affective measures over the assessment week were aggregated per individual. Afterward, we conducted a principal component analysis with varimax rotation on between-individual z-scores. The analysis identified two major factors, which together explained 85.8% of the total variance of trait-level affective overall experience. Six items (*angry, sad, anxious, bored, lonely,* and *apathetic*) loaded heavily on the first factor, forming the *Negative Affectivity* (meanNA) scale, which explained 46.2% of total variance. Four items (*happy, cheerful, joyful,* and *in a good mood*) loaded heavily in the second factor, and formed the *Positive Affectivity* (meanPA) scale, which explained 39.7% of between-individual variance. Both scales showed good reliability (Cronbach's α = .97 for meanPA, and Cronbach's α = .95 for meanNA). Scores on both measures can range from 0 to 12, with lower scores reflecting low overall positive and negative affectivity, and higher scores high affectivity.

Variations in PA (vPA): We created a person-level variable based on the intraindividual standard deviation of momentary PA measures reported during the assessment week. Higher scores reflect greater variations in PA, i.e., the student's PA levels shifted frequently between high and low levels, whereas lower scores reflect greater stability in PA levels throughout the week.

Variations in NA (vNA): We created a person-level variable based on the intraindividual standard deviation of momentary NA measures reported during the assessment week. Higher scores reflect greater variations in NA, i.e., the student's negative affect shifted frequently between high and low NA levels, whereas lower scores reflect greater stability in momentary NA between reports.

Autotelic Personality: we calculated the individual means of *effortless attention, motivation,* and *positive affect* for each participant. Afterward, we calculated the autotelic personality score based on the average of these measures. Scores on this scale range from 0 to 12, with higher scores representing individuals who are happier, can more easily concentrate and are more intrinsically motivated in their daily lives.

Salivary Cortisol

The diurnal pattern of cortisol shows a rapid elevation in the first hour after awakening, followed by a slower decline throughout the day. This pattern results in a very skewed distribution. To correct this, cortisol values underwent a natural log transformation before analyses. The associations between cortisol and other state and trait variables were analyzed in two ways:

1. *Within-individual variability*: we analyzed the associations between momentary subjective experience, personality characteristics and company in relation to cortisol responses.

2. *Cortisol awakening response*: we calculated the cortisol awakening response as the difference between the first sample after awakening and the sample gathered 30-50minutes after awakening.

Based on evidence that a variety of exogenous and endogenous factors can influence cortisol secretion (Nicolson, 2007), we assessed confounders at the beep level (recent intake of food, medication and alcohol), at the day level (time of awakening), and at the person level (waist-hip ratio, body mass index, contraceptive pill use).

Statistical Analyses

Multilevel Model (MLM)

We performed multilevel analyses to investigate the associations between cortisol, state variables, company and person-level variables. Multilevel regression is a variant of linear modeling, appropriate for hierarchically clustered data (for a review, see Snijders & Bosker, 2003). Multilevel regression allows the estimation of models for random-sampling designs, in the presence of missing data, unlike other longitudinal analyses. The weight of each individual or day is determined according to the amount of information available.

The models used had three levels: beep level, day level and person level. Dependencies among the outcome measures occur because observations tend to be more similar if taken on the same day or if taken from the same participant. Therefore, we modeled random intercepts at the day level and the person level in all analyses and added a random effect for time to allow for person-specific slopes. Inclusion of random effects for other variables did not improve the model fit, as assessed with likelihood ratio tests. To assess the significance of the regression coefficients for the fixed effects, z-scores were calculated by dividing the estimated effect by its standard error. This ratio is approximately normally distributed. Two-tailed tests were used even when hypothesis were directional. Significance levels were set as alpha=.05.

We centered beep-level variables (e.g., PA, NA) around the individual mean. The interpretation of results is clearer when beep-level variables are centered around the individual mean, as the effects of individual changes and variations are clearly distinguished from possible group effects (Enders & Tofighi, 2007). Person-level variables (e.g., meanPA, meanNA) were centered on the grand mean.

Momentary experience.

We estimated separate multilevel models for each momentary variable, using time and possible confounders (use of contraceptive, current residence and first year of college) as predictors. Previous research has shown that time of day and person-level characteristics can influence female college students' affective experience and fatigue levels in daily life (e.g., Kahneman & Krueger, 2006; Watson & Pennebaker, 1989). For example, the use of contraceptive pill has been associated with adverse mood effects, although this finding is not consistent (Borgstrom, Kask, Gulinello, Odlind, & Sundstrom-Poromaa, 2008; Borgstrom, Odlind, Ekselius, & Sundstrom-Poromaa, 2008; Jarva & Oinonen, 2007; Kurshan & Neill Epperson, 2006; Oinonen & Mazmanian, 2002). Moving away from the parents home when going to college and being a freshman have also shown associations with increased negative affect and decreased well-being (e.g., Dyson & Renk, 2006; van Rooijen, 1986; Vredenburg, et al., 1988).

In preliminary models, we estimated the effects of time on subjective experience, because of possible associations shown in other studies (e.g., Kahneman & Krueger, 2006) between times of day and subjective experience and fatigue (for estimation models of effects of time, see Appendix C). A quadratic function of time improved the models of all variables of subjective experience, except for levels of self-consciousness and importance, which were more fully explain by a linear function of time. Table 1 shows estimated effects of possible confounders on subjective experience. None of the confounders showed a significant effect on variables of subjective experience.

Salivary cortisol.

To correct for the diurnal pattern of cortisol, we estimated a multilevel regression using a four-degree polynomial function of time; addition of higher order polynomial terms did not improve model fit, as ascertained with likelihood ratio tests (see Appendix C). A dummy variable *recent awakening* was created (1 *samples collected within the first hour after awakening*; 0 *other situation*) to control for the cortisol awakening response (CAR). The dummy variable *recent meal* was created (1 *sample collected within one hour after a meal*; 0 *other situation*) to control for possible effects

of food intake. We included other predictors at the beep level (recent meal, and alcohol) and at the person level (waist-hip ratio, body mass index, contraceptive pill use) in preliminary models. We estimated separate models to account for independent effects of different confounders. None of the confounders was significantly associated with cortisol (Table 2).

Table 1 *Multilevel Regression Estimates for Fixed Effects of Time and Other Confounders on Momentary Subjective Experience*.

	B (SE)					
Outcome	Intercept	Time	Time^2	C. Pill	MH	First year
Positive affect	7.46(.43)***	.04(.01)**	-.01(.00)***	-.38(.44)	-.43(.41)	-.26(.45)
Negative affect	2.59(.51)***	-.02(.01)*	.01(.00)*	.55(.52)	-.73(.49)	.73(.49)
Motivation	8.00(.54)***	.03(.03)	.02(.01)**	-.23(.55)	-.30(.52)	.18(.56)
Effortless attention	7.54(.41)***	.05(.02)***	-.01(.00)***	-.33(.42)	.30(.39)	.40(.43)
Fatigue	4.18(.60)***	-.07(.02)***	.04(.00)***	.66(.61)	-.11(.57)	-.70(.62)
Self-consciousness	3.62(.50)***	.04(.02)*	-.00(.00)	.72(.51)	-.07(.48)	.06(.52)
Creativity	3.83(.55)***	.01(.01)	-.01(.00)***	.86(.56)	-.25(.52)	.55(.58)
Importance	4.05(.50)***	-.05(.02)*	-.00(.01)	.80(.50)	.28(.47)	.12(.52)
Control	7.73(.61)***	-.02(.01)	-.00(.00)	-.35(.62)	-1.09(.58)†	-.69(.64)
Challenge	4.30(.47)***	.02(.02)	-.02(.01)***	.53(.48)	.04(.45)	-.87(.49)†
Skills	8.97(.49)***	.04(.01)*	-.01(.00)	-1.15(.49)*	-.38(.46)	.04(.51)
BL	7.60(.57)***	.03(.01)*	-.01(.00)**	-.99(.57)†	-.31(.53)	-.24(.60)
EL	4.40(.54)***	.03(.02)	-.01(.01)†	1.08(.55)*	-.09(.51)	-.71(.56)

Note. C. Pill (Contraceptive pill - 1=doesn't use), Home (1=moved from parents' home) and First year (1=first year of college) were dummy coded. Time was centered on the mean of all sampling times (15:08). The models include 2270 ESM observations, nested within 67 subjects.
EL - Engagement levels; BL - Balance level; B - unstandardized regression coefficient; SE - standard error.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table 2 *Multilevel Model Estimates for Fixed Effects of Time and Other Confounders on Cortisol*.

			95% Confidence Interval	
	B	SE	Lower	Upper
Intercept	1.53 ***	.21	1.12	1.94
Time	-.12 ***	.01	-.15	-.10
Time2	.01 ***	.00	.01	.02
Time3	-.00*	.00	-.00	-.00
Time4	-.00	.00	-.00	.00
Recent waking	-.01	.09	-.19	.18
Recent meal	.07	.05	-.03	.17
C. Pill	-.13	.12	-.36	.09
MH	.04	.11	-.17	.26
First year	.04	.12	-.21	.28
Tobacco	-.24	.19	-.60	.13

			95% Confidence Interval	
Random-effects		*B* (SE)	Lower	Upper
Person-level	Time	.04 (.01)	.02	.05
	Intercept	.35 (.04)	.27	.44
Day-level	Intercept	.16 (.03)	.10	.24
	Residual	.63 (.01)	.60	.66

Note. The dependent variable is log-cortisol. Variables with non-significant effects (recent waking, recent meal, contraceptive, home, first year of college and tobacco use) in preliminary analyses were excluded. Time was centered on the mean of all sampling times (15:08). C. Pill (Contraceptive pill - 1=doesn't use), MH (1=moved from parents home) and First year (1=first year of college) were dummy coded. The model includes 2270 ESM observations and 1693 cortisol measures nested within 67 subjects.

B - unstandardized regression coefficient; SE - standard error.

$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Chapter 4: The Flow State: Everyday Experience and Physiological Function

"We are what we repeatedly do. Excellence, then, is not an act, but a habit."
Aristotle

The aim of this chapter was to investigate how the flow state was associated with the affective, cognitive and motivational components of experience, daily contexts, and neuroendocrine activation. In Chapter 1, we discussed some limitations to the assessment of the flow state based solely on the balance between challenges and skills using categorical and continuous operationalizations of flow. We expected that the assessment of the flow state based on external (balance) and internal (autotelicity) components of experience would be associated with a more intense experience of flow and engagement. If this were the case, engagement levels could be used to investigate the psychophysiological experience of flow. Also, one of our aims was to investigate the associations between engagement levels, psycho-affective experience and daily contexts.

Study activities are often associated with the highest challenges, compared to other daily activities. However, regardless of the perception of adequate skills to match the demands, study activities have been associated with low enjoyment and motivation (e.g., Allison & Duncan, 1988; Csikszentmihalyi, 2002; Delle Fave & Massimini, 1988; Delle Fave, et al., 2011; Salanova, et al., 2006). Researchers have explained these findings in terms of negative meanings and attitudes toward work and the perception that these activities are not self-determined (e.g., Asakawa & Csikszentmihalyi, 2000; Delle Fave, et al., 2011; Nakamura, 1988). However, we proposed that the lack of attentional resources and interest might also account for the worst experience of study. Internal resources – attention and interest – can lead individuals to perceive the activities as effortless, even if they are fully engaged in the task (Hommel, 2011; Ryan & Decu, 2008). Therefore, we expected that study activities in which external and internal components are available would be associated

with a better subjective experience in study activities characterized for example, by higher PA and lower NA, higher creativity and less fatigue.

In addition, we studied the context of solitude, which has been associated with the most negative and positive experiences in daily life (e.g., Averill & Long, 2003; Larson, 1990). This context can be particularly negative for individuals going through adaptation processes, such as starting college. We expected that experiencing engagement in solitude would ameliorate the negative affective experience associated with solitude by bringing order to consciousness as the focus in the task at hand prevents individuals from worrying about themselves and others. Therefore, engagement in solitude would lead to, for example, greater positive affect and creativity and lower negative affect and fatigue.

Finally, we investigated the associations between affective experience, solitude, and cortisol. Previous studies found that positive affect is associated with lower cortisol levels, whereas negative affect shows the opposite pattern (e.g., Adam, 2006; Jacobs, et al., 2007; Polk, et al., 2005; Smyth, et al., 1998). Also, there was evidence from other studies that solitude is associated with higher cortisol levels (Adam, 2006), including a previous study using a smaller subset of this sample (Matias, et al., 2011). Hence, we hypothesized that solitude would be associated with higher cortisol levels in this larger sample. There is no evidence that activities are associated with cortisol changes. Therefore, we did not investigate cortisol changes in relation to the activity participants were involved in.

The Associations Between Momentary Experience, Engagement, and Daily Contexts

Balanced and Autotelic Experiences in Daily Life: Associations with Momentary Subjective Experience

We estimated separate ML models to investigate how the interaction between momentary levels of balance and autotelicity was associated with changes in momentary subjective experience. Table 3 shows the associations between levels of balance, autotelicity, and their interaction on momentary experience.

In activities perceived as being more balanced, students experienced greater PA, effortless attention, perceived skills, and felt more creative; also, students felt less NA, fatigue and motivation. Also, they perceived more control over what they were doing, and perceived the activity as more challenging and important to their goals. High autotelicity levels were associated with increases in PA, effortless attention, motivation, creativity, self-consciousness, perceived control and skills; autotelicity levels were also associated with lower levels of perceived challenges, NA, and fatigue.

Finally, the concurrent increase in autotelicity and balance levels was associated with increases in motivation, self-consciousness, fatigue, and decreases in the perception of the importance of the activity. Overall, students were more motivated, self-conscious and felt more tired in situations in which they perceived higher balance and autotelicity, compared to lower levels of balance and autotelicity.

Engagement levels and momentary subjective experience.

After establishing that there were significant interaction effects of balance and autotelicity on momentary psycho-affective experience, namely the improvement of motivation, we performed a multilevel regression analysis to analyze the independent effects of the levels of engagement (EL = BL*AL) on experience (Table 4). Results show that engagement levels were associated with increased PA, motivation, effortless attention, creativity, control, and perceived importance, challenges, skills and balance in the activity; also, engagement was associated with decreased NA and fatigue.

Table 3 *Multilevel Regression Estimates for Effects of Autotelicity Levels on the Association Between Balance Levels and Momentary Subjective Experience*.

	B (SE)			
Outcome	Intercept	BL	AL	BL*AL
Positive affect (PA)	6.96 (.19)***	.06 (.01)***	.14 (.01)***	-.00 (.00)
Negative affect (NA)	2.61 (.00)***	-.03 (.01)***	-.11 (.01)***	-.00 (.00)
Motivation	8.05 (.25)***	-.12 (.02)***	1.04 (.02)***	.02 (.01)***
Effortless attention	7.70 (.19)***	.10 (.01)***	.47 (.01)***	-.00 (.00)
Fatigue	3.83 (.26)***	-.10 (.01)***	-.14 (.01)***	.01 (.00)*
Self-consciousness	4.04 (.25)***	-.01 (.02)	.07 (.02)***	.01 (.01)*
Creativity	4.34 (.24)***	.10 (.01)***	.07 (.01)***	-.01 (.00)
Importance	4.41 (.25)***	.44 (.02)***	-.03 (.02)	-.02 (.01)**
Control	6.62 (.27)***	.10 (.01)***	.20 (.01)***	-.00 (.00)
Challenge	3.73 (.22)***	.91 (.01)***	-.03 (.01)***	.00 (.00)
Skills	8.15 (.25)***	.11 (.01)***	.19 (.01)***	-.01 (.00)

Note. Separate multilevel models were estimated for each outcome. Models control the effects of Time (centered on the mean of all sampling times - 15:08). Models include 2270 ESM observations measures nested within 67 subjects. Balance levels (BL) and autotelicity levels (AL) were centered on the intraindividual mean.
B - unstandardized regression coefficient; SE - standard error.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table 4 *Multilevel Regression Estimates for Fixed Effects of the Levels of Engagement on Momentary Subjective Experience.*

			95% C.I.	
Outcome	*B*	SE	lower	upper
Positive affect (PA)	.11***	.01	.09	.13
Negative affect (NA)	-.08***	.01	-.10	-.07
Motivation	.30***	.03	.24	.35
Effortless attention	.28***	.01	.25	.31
Fatigue	-.13***	.01	-.16	-.11
Self-consciousness	.02	.02	-.02	.06
Creativity	.11***	.01	.09	.14
Importance	.34***	.02	.30	.38
Control	.15***	.01	.12	.18
Challenges	.71***	.01	.69	.74
Skills	.15***	.01	.12	.18
Balance levels (BL)	.82***	.01	.80	.84

Note. Separate multilevel models were estimated for each outcome. Models control for effects of Time (centered on the mean of all sampling times - 15:08). Engagement levels (EL) variable was centered on the intraindividual mean. Models includes 2270 ESM observations measures nested within 67 subjects. PA - Positive affect; NA - Negative affect. *B* - unstandardized regression coefficient; SE - standard error.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Engaging Experiences and Daily Contexts

We observed that students experienced overall improvements in psycho-affective experience as their engagement levels increased. However, how did these associations translate in the experience of daily contexts? To answer this question, we examined the associations between engagement and the affective, physical, cognitive and motivational components of experience in relation to the company (*alone* vs *not alone*) and activities (*study* vs. *not study*) participants reported during the assessment week.

In our sample, participants reported spending on average 38% of their time alone and 27% of their time studying. We hypothesized that being highly engaged in these

contexts would be associated with improvements in participants' psycho-affective experience. To investigate possible moderation effects of levels of engagement on the associations between solitude (Figure 7), study activities (Figure 8) and momentary experience, we followed the steps of moderation models proposed by Baron and Kenny (1986).

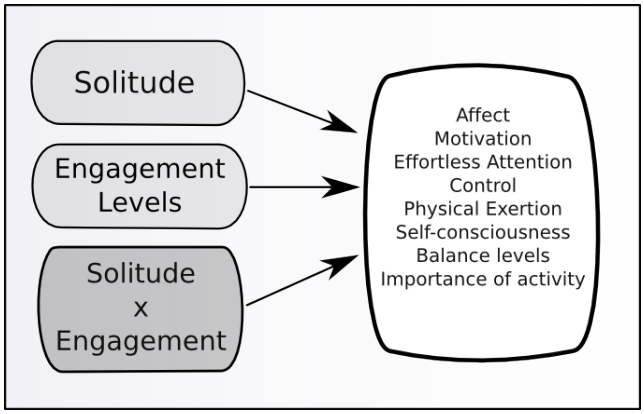

Figure 7 - Moderation model of the effects of momentary engagement levels on the association between daily solitude and subjective experience.

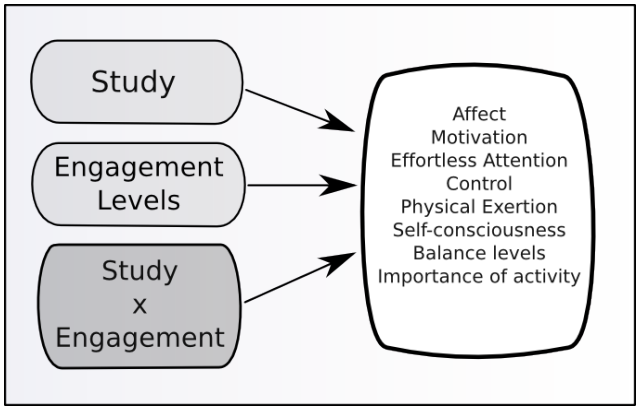

Figure 8 - Moderation model of the effects of momentary engagement levels on the association between daily study activities and subjective experience.

Daily Solitude

How do female college students spend their time alone? Figure 9 shows the activities reported by participants in solitude. Overall, students spent most of their time alone in leisure (e.g., reading a book, writing, watching TV), maintenance (e.g., eating, house chores, personal care), and study activities. Participants were also involved in social interactions while they were physically alone. This finding is not surprising if

we take into account the widespread availability of means of communication. A closer analysis of the social interactions showed us that the Internet (email, chat) and text messages were the preferred ways to communicate with others (70.3%), followed by the telephone (29.7%). Of all ESF in which participants reported being alone and in social-related activities, 81% report talking with other people (17.2% don't identify the means of communication), 13.8% of times, participants were looking or waiting for someone, and in 5.2% of reports, they were playing with pets. Of all participants, only 33 reported being in a social-related activity in solitude, with an average of one report per participant.

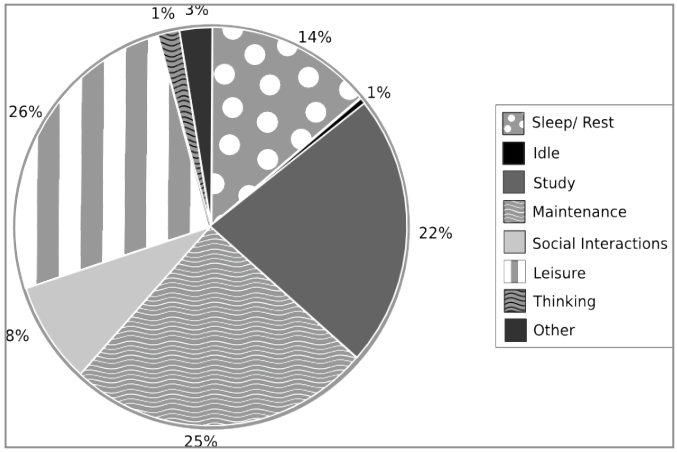

Figure 9 - Description of activities students are involved in while alone.

We chose to analyze the ESFs in which participants reported being alone without distinguishing between activities. We acknowledge that different activities impact individual experience in different ways. However, the number of reports in each activity category in solitude was insufficient to provide a clear picture of the impact of different activities on the experience of solitude.

Effects of solitude on momentary experience.

First, we estimated separate multilevel models to investigate the associations between solitude and momentary subjective experience. Results (Table 5) showed that participants experienced lower levels of PA and higher NA in solitude, compared to

being with other people. Participants showed lower creativity and higher fatigue and self-consciousness. Solitude was associated with activities that were perceived as less important for goals in which there were lower challenges, skills, and lower balance, than activities done with other people. Finally, participants experienced lower levels of engagement in solitude, compared to other company.

Table 5 *Multilevel Regression Estimates for Fixed Effects of Solitude on Momentary Subjective Experience*.

			95% Confidence Interval	
Outcome	*B*	SE	Lower	Upper
Positive affect (PA)	-.69***	.07	-.83	-.55
Negative affect (NA)	.60***	.06	.48	.71
Motivation	-.13	.19	-.49	.24
Effortless attention	-.18	.10	-.40	.04
Fatigue	.57***	.10	.38	.76
Self-consciousness	.28*	.14	.02	.55
Creativity	-.23*	.09	-.41	-.05
Importance	-.41**	.16	-.71	-.10
Control	-.05	.10	-.25	.16
Challenges	-1.05***	.14	-1.33	-.78
Skills	-.29**	.11	-.50	-.08
Balance levels	-1.09***	.15	-1.38	-.80
Engagement levels	-.88***	.16	-1.30	-.69

Notes. Models control the effects of time. Time was centered on the mean of all sampling times (15:08). Solitude (1 alone) was dummy coded. The models include 2270 ESM observations, nested within 67 subjects.
B - unstandardized regression coefficient; SE - standard error.
†*p*<.10. *p<.05. **p<.01. ***p<.001.

Do engaging experiences promote a more positive experience of solitude?

We estimated separate multilevel models to investigate the associations between EL and the subjective experience of solitude. Table 6 shows that levels of engagement moderated the effects of being alone on feelings of creativity, motivation, fatigue and perceived balance. There were also marginally significant effects on perceived control.

Table 6 *Multilevel Regression Estimates for the Effects of Engagement Levels on the Association Between Solitude and Momentary Subjective Experience*.

	B (SE)			
Outcome	Intercept	Solitude	EL	EL*Solitude
Positive affect (PA)	7.17 (.19)***	-.59 (.07)***	.09 (.01)***	.03 (.02)
Negative affect (NA)	2.44 (.23)***	.53 (.06)***	-.07 (.01)***	-.01 (.02)
Motivation	7.93 (.26)***	.17 (.18)	.34 (.03)***	-.11 (.05)*
Effortless Attention	7.72 (.19)***	-.12 (.11)	.26 (.02)***	.04 (.03)
Fatigue	3.64 (.26)***	.45 (.10)***	-.09 (.02)***	-.08 (.03)**
Self-consciousness	3.91 (.25)***	.34 (.14)**	.04 (.03)†	-.04 (.04)
Creativity	4.39 (.25)***	-.12 (.09)	.08 (.02)***	.07 (.03)**
Importance	4.43 (.26)***	-.05 (.15)	.34 (.03)***	-.01 (.04)
Control	6.61 (.27)***	.11 (.10)	.13 (.02)***	.06 (.03)†
Challenges	3.90 (.23)***	-.32 (.09)***	.70 (.02)***	.03 (.03)
Skills	8.17 (.26)***	-.14 (.11)	.13 (.02)***	.04 (.03)
Balance levels	4.27 (.24)***	-.26 (.07)***	.80 (.01)***	.04 (.02)*

Notes. Models control the effects of time. Time was centered on the mean of all sampling times (15:08). Engagement levels variable (EL) was centered on the intraindividual level. Solitude (1 *alone*) was dummy coded. The models include 2270 ESM observations, nested within 67 subjects.
B - unstandardized regression coefficient; SE - standard error.
†$p < .10$. *$p < .05$. **$p < .01$. ***$p < .001$.

Post hoc analyses showed that the moderating effects of EL on the associations between solitude and momentary experience counteracted some of the main effects of solitude (see Appendix E). Students felt higher fatigue and less creative and motivated alone than not alone. However, students who experienced high levels of engagement felt as tired and creative as in contexts in which they were not alone. However, in situations in which students experienced low engagement in solitude they also showed greater motivation levels than in other social contexts.

Daily Study Activities

What different study activities do female college students participate in? Overall, most activities reported by participants were related to classroom activities (56.5%) and homework (42.0%).

Effects of study activities on momentary experience.

We estimated separate multilevel models to determine the associations between study activities and momentary subjective experience. Results (Table 7) show that participants experienced greater levels of creativity and lower levels of PA, motivation, control and self-consciousness in study, compared to non-study. Study activities were also associated with increased perception of importance, levels of balance and challenges, but lower skills. Finally, study activities were associated with higher engagement than non-study activities.

Do engaging experiences promote a more positive experience in study activities?

Next, we investigated possible moderation effects of levels of engagement on the momentary experience of study activities. Results (Table 8) show that levels of engagement were associated with changes in effortless attention, motivation, self-consciousness, challenges, and levels of balance in study activities.

Post hoc analyses (see Appendix E) showed that increases in levels of engagement were associated with higher motivation and effortless attention, and with lower levels of self-consciousness, perceived challenges and balance in study activities, compared to non-study activities. Results showed that, as levels of engagement increase in study activities, students‘ cognitive and motivational experience improved in comparison to non-study activities. At the same time, their perceptions of challenges and balance became increasingly similar to those in non-study activities, although perceived challenges and balance were always higher in study compared to other activities.

Table 7 *Multilevel Regression Estimates for Fixed Effects of Study Activities on Momentary Subjective Experience*.

			95% Confidence Interval	
Outcome	*B*	SE	Lower	Upper
Positive affect (PA)	-.19***	.08	-.34	-.03
Negative affect (NA)	.12	.07	-.04	.22
Motivation	-2.72***	.20	-3.12	-2.33
Effortless Attention	-.04	.13	-.29	.21
Fatigue	.06	.11	-.16	.28
Self-consciousness	-1.15***	.15	-1.45	-.86
Creativity	.29**	.10	.09	.49
Importance of the activity	3.59**	.15	3.29	3.90
Control	-.39***	.12	-.62	-.15
Challenges	2.32***	.15	2.03	2.62
Skills	-.51***	.12	-.75	-.28
Balance levels	2.18***	.16	1.87	2.50
Engagement levels	1.22***	.18	.87	1.56

Notes. Models control the effects of time. Time was centered on the mean of all sampling times (15:08). Study (1 *study*) was dummy coded. The models include 2270 ESM observations, nested within 67 subjects.

B - unstandardized regression coefficient; SE - standard error.

$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table 8 *Multilevel Regression Estimates for Effects of Engagement Levels on the Associations Between Study and Momentary Subjective Experience*.

	B (SE)			
Outcome	Intercept	Study	EL	EL*Study
Positive affect (PA)	6.55 (.19)***	-.31 (.13)*	.12 (.01)***	-.01 (.02)
Negative affect (NA)	2.59 (.23)***	.19 (.07)**	-.09 (.01)***	-.00 (.02)
Motivation	8.84 (.26)***	-3.35 (.20)***	.28 (.03)***	.31 (.06)***
Effortless attention	7.86 (.18)***	-.53 (.12)***	.24 (.02)***	.21 (.18)***
Fatigue	3.75 (.26)***	.23 (.11)*	-.14 (.01)***	-.00 (.03)
Self-consciousness	3.36 (.25)***	-1.13 (.16)***	.07 (.02)**	-.12 (.05)*
Creativity	4.30 (.25)***	.15 (.10)	.12 (.01)***	-.04 (.03)
Importance	3.56 (.24)***	3.29 (.15)***	.29 (.02)***	-.04 (.05)
Control	6.80 (.27)***	-.62 (.12)***	.15 (.02)***	.06 (.04)
Challenges	3.39 (.22)***	1.57 (.10)***	.72 (.01)***	-.14 (.03)***
Skills	8.31 (.26)***	-.77 (.12)***	.15 (.02)***	.06 (.04)†
Balance levels	3.85 (.23)***	1.31 (.08)***	.84 (.01)***	-.18 (.02)***

Notes. Models control the effects of time. Time was centered on the mean of all sampling times (15:08). Engagement levels variable (EL) was centered on the intraindividual mean. Study (1 study) was dummy coded. The models include 2270 ESM observations, nested within 67 subjects.
B - unstandardized regression coefficient; SE - standard error.
†$p < .10$. *$p < .05$. **$p < .01$. ***$p < .001$.

Cortisol and the Everyday Life Experience

The second main aim of the present chapter concerned the associations between daily life experience, solitude and cortisol. Therefore, we investigated whether momentary affective experience and solitude were associated with cortisol.

Momentary Experience and Cortisol

We tested separate multilevel models for affective experience. Results showed that NA and PA were significantly associated with cortisol. Although NA lost its

significant association with cortisol when PA was introduced in the model, we kept NA in further analyses. Findings showed that greater negative affect and lower positive affect were associated with higher cortisol levels (Table 9).

Table 9 *Multilevel Regression Estimates for Fixed Effects of Momentary Affect (PA and NA) on Cortisol.*

	B (SE)		
	Model 1	Model 2	Model 3
Intercept	1.37 (.05)***	1.37 (.05)***	1.37 (.05)***
Negative affect (NA)	.03 (.01)*		.01 (.01)
Positive affect (PA)		-.03 (.01)**	-.03 (.01)*

Notes. The dependent variable is log-cortisol. Variables with non-significant effects (recent waking, recent meal, contraceptive, and tobacco use) in preliminary analyses were excluded. Models control the effects of time. Time was centered on the mean of all sampling times (15:08). Negative affect (NA) and positive affect (PA) were centered on the intraindividual mean. The model includes 2270 ESM observations and 1693 cortisol measures nested within 67 subjects.
B - unstandardized regression coefficient; SE - standard error.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Engagement levels and cortisol.

Next, we investigated whether high levels of engagement were associated with momentary cortisol changes. Results (Table 10) show that there was no significant association between EL and cortisol.

We tested a separate multilevel model with EL as the sole predictor for cortisol, to ascertain whether the effects of affect caused the non-significant association between EL and cortisol. However, the association between EL and cortisol remained non-significant (B = .00, SE = .00, p = .854). Therefore, we excluded EL from further analyses.

Table 10 *Multilevel Regression Estimates for Fixed Effects of Engagement Levels and Affect (PA and NA) on Cortisol.*

			95% C.I.		
	B	SE	Lower	Upper	Interpretation
Intercept	1.37***	.05	1.27	1.47	3.94nmol/L[a]
Engagement levels	.01	.00	-.00	.02	*n.s.*
Negative affect (NA)	.02	.01	-.01	.05	*n.s.*
Positive affect (PA)	-.03*	.01	-.06	-.00	-3% per scale point[b]

Random effects parameters				95% C.I.	
		B	SE	lower	upper
Person-level	Time	.03	.01	.02	.05
	Intercept	.32	.04	.26	.40
Day-level	Intercept	.14	.03	.09	.23
	Residual	.67	.01	.64	.69

Notes. The dependent variable is log-cortisol. Variables with non-significant effects (recent waking, recent meal, contraceptive, and tobacco use) in preliminary analyses were excluded. Model controls for the effects of time. Time was centered on the mean of all sampling times (15:08). Engagement levels (EL), negative affect (NA) and positive affect (PA) were centered on the intraindividual mean. The model includes 2270 ESM observations and 1693 cortisol measures nested within 67 subjects.
C.I. – Confidence Interval; *B* - unstandardized regression coefficient; SE - standard error.
[a] The exponential transformation of the log-cortisol value for the intercept returned this value to nmol/l.
[b] B_{change}= [Exp(*B*)]-1.
†*p* < .10. **p* < .05. ***p* < .01. ****p* < .001.

Daily Solitude and Cortisol

Our final question concerned the association between the experience of solitude and cortisol. Being alone has been associated with higher negative affect and lower positive affect (e.g., Larson, 1990). These variables were also associated with momentary cortisol levels. Therefore, we examined whether the association between solitude and cortisol was mediated by momentary affective experience associated with being alone. We followed the steps proposed by Baron and Kenny (1986) for mediation models. We expected that affect could mediate the association of solitude and cortisol.

First, we determined whether solitude was associated with changes in cortisol. Results showed that solitude was significantly associated with greater cortisol levels (B = .10, SE = .04, p < .01). This change translates into an 11% increase in cortisol levels when individuals were alone, compared to when they were not alone[1]. Next, we tested whether affect mediated the effect of solitude on cortisol. Table 11 shows that the association between solitude and cortisol was only partially mediated by affect.

Table 11 *Multilevel Regression Estimates of the Fixed Effects of Solitude and Momentary Affect (PA and NA) on Cortisol.*

			95% C.I.		
	B	SE	Lower	Upper	Interpretation
Intercept	1.34***	.05	1.24	1.44	3.82nmol/l[a]
Solitude	.08*	.04	.01	.15	+8% when alone [b]
Negative affect (NA)	.01	.01	-.02	.04	n.s.
Positive affect (PA)	-.02†	.01	-.05	.00	-2% per scale point [b]

Random effects parameters				95% Confidence Interval	
		B	SE	Lower	Upper
Person-level	Time	.03	.01	.02	.05
	Intercept	.33	.03	.27	.41
Day-level	Intercept	.14	.03	.09	.22
	Residual	.67	.01	.64	.69

Notes. The dependent variable is log-cortisol. Variables with non-significant effects (recent waking, recent meal, contraceptive, home, first year of college and tobacco use) in preliminary analyses were excluded. Model controls the effects of time. Time was centered on the mean of all sampling times (15:08). Negative affect (NA) and positive affect (PA) were centered on the intraindividual mean. Solitude (1 alone) was dummy coded. The model includes 2270 ESM observations and 1693 cortisol measures nested within 67 subjects.
C.I. – Confidence Interval; *B* - unstandardized regression coefficient; SE - standard error.
[a] The exponential transformation of the log-cortisol value for the intercept returned this value to nmol/l.
[b] B_{change}= [Exp(*B*)]-1.
†*p*<.10. * *p*<.05. **p<.01. ***p<.001.

[1] Percent change in untransformed cortisol per unit change in predictor B_{change} = [exp(*B*)] – 1.

Discussion

In line with our expectations, in contexts in which college women experienced higher engagement, they had more positive experiences than in contexts in which engagement was low: participants experienced greater positive affect and lower negative affect, they felt more motivated and creative, experienced higher levels of effortless attention, and felt less fatigue. Engagement was associated with contexts that students perceived as having more control over and being more important to their immediate and future goals. Also, findings showed that engagement was associated with differences in the subjective experience of distinct daily contexts. In daily solitude, young women experienced greater PA and lower NA when highly engaged in the task. In study activities, engagement was associated with greater effortless attention, motivation, and lower of self-consciousness.

Engagement in Daily Life: The Role of Balance and Autotelicity to the Assessment of the Flow State

The expected associations between levels of balance, levels of autotelicity, and momentary psycho-affective experience were observed in this study: autotelicity and balance complemented each other by heightening cognitive, motivational and affective momentary experience.

The balance between challenges and skills was not associated with increased motivation, enjoyment, and willingness to be in the activity. Previous studies showed that individuals tend to experience lower intrinsic motivation and enjoyment, regardless of the presence of optimal conditions for the experience of flow, in particular in the context of productive activities (e.g., Csikszentmihalyi, 1997a; Delle Fave, et al., 2011). These findings might be explained by cultural and personal meanings about the activities at hand, the perceived importance of the activity for the individual's goals, the availability of energetic resources, and personal preferences to take part in challenging tasks.

The perceived importance of the task for immediate and long-term goals influences how balanced experiences lead to an engaging experience of flow: perceiving that the importance is low can lead to an intense flow experience in the presence of high challenges and skills; however, the perception of high importance can threaten the individual sense of self, which hinders affective, motivational, and cognitive functioning (Engeser & Rheinberg, 2008). This can influence whether people will pursue, or abandon certain activities, and whether these are experienced in a positive or negative way. Internal processes, such as the availability of energetic resources and interest in the task, may also explain the negative association between levels of balance and motivation. High levels of challenges and skills provide optimal conditions for the flow state, but they do not always ensure that a flow state will follow (Engeser & Rheinberg, 2008; Moneta & Csikszentmihalyi, 1996; Schmidt, et al., 2007). The flow state depends of external opportunities (i.e., manageable challenges) and internal resources (e.g., adequate attentional resources, interest, and enjoyment). Interest and enjoyment have important roles in the experience of effortless attention in challenging activities (McGuire & Botvinick, 2011). The flow state requires the deployment of attentional resources (Csikszentmihalyi, 1997a, 2002; Csikszentmihalyi & Nakamura, 2011; Nakamura & Csikszentmihalyi, 2002); however, attentional resources exist in limited supply, and individuals perceive challenging contexts as stressful and effortful if these resources are not readily available.

Lastly, some individuals experience strain and anxiety as they participate in highly challenging activities, even when they perceive adequate skills for the task. For example, individuals with non-autotelic personalities, or motives of "*fear of failure*" prefer to be in low challenging situations and avoid challenges because these are perceived as threatening to their personal sense of self, they prefer situations in which they can succeed, even at the cost of personal growth and development. However, other individuals with autotelic personality and "*hope of success*" will experience heightened positive affect, effortless attention, motivation, and loss of self-consciousness in balanced experiences (Adlai-Gail, 1994; Dweck & Leggett, 1988; Salanova, et al., 2006). Therefore, to ensure we assess an experience of intense motivation and effortless activation, as proposed by the flow theory, it is necessary to

include internal conditions in the measure of the flow state in daily life, in addition to the more external dimensions of flow.

In spite of the limitations of assessing flow with an operationalization based on balance levels, our results confirmed that the interaction between challenges and skills were an important condition to the emergence of the flow state. The flow state has a dynamic nature, changing as the balance between challenges and skills is altered, as psychic resources are deployed, and interest changes. This constant process makes this experience elusive to researchers who attempt to assess it in daily life. The independent associations of balance and autotelicity levels with momentary cognitive, motivational, and affective experience reflect this chaotic and dynamic process that occurs as the individual interacts with his, or her, environment. For example, we found that participants experienced an increase in self-consciousness in situations with lower challenges and higher autotelicity. This leads us to believe that, as participants mastered current challenges, their interest and attention were kept high; during those situations, students could either adjust the levels of challenges, or abandon the activity. As individuals leave the flow state, the merging of action-awareness and the perception of conscious self re-emerges, and students focus on their feelings, behaviors, and performance. This focus on the self is only avoided when challenges are high and attention is focused completely on the task at hand. We confirmed that high challenges were associated with lower self-consciousness in our study: students thought less about themselves when facing challenging tasks. Although the flow theory proposes that levels of self-consciousness should be low in a flow state, experience sampling studies have often observed heightened self-consciousness in balanced experiences. In a recent study with college students (Freire & Matias, 2008), the subjective experience of flow was assessed using retrospective (spontaneously identified by individuals) and online (the most intense flow experience reported during the ESM assessment week) assessments of flow experiences. Students reported loss of self-consciousness in flow experiences that they identified spontaneously; however, they did not report loss of self-consciousness in reports of flow experiences assessed with the ESM. This suggests that individuals already interpreted experiences that they report retrospectively as being flow in a more positive light; however, in reports of experiences that occur in daily life, assessed with the ESM, these attribution processes

do not contaminate reports, because they occur closer to the individual immediate experience. In fact, in daily life, moderate levels of self-consciousness might be important to assess performance and adjust external and internal resources (Blais, 2011; Dietrich, 2004), even if individuals are not consciously aware of these self-conscious processes retrospectively. The differences found between the momentary experience of balanced experiences and the retrospective reports of flow experiences provided important clues as to processes associated to the flow state in daily life.

In the current study we confirmed that the assessment of states of intense engagement should include external and internal components of experience. Therefore, using a variable of engagement provides a measure that can be associated with other physiological measures in the assessment of the psychophysiology of flow.

In sum, current findings shed new light into the discussion about the differences found in the flow state assessed in daily life and retrospectively, and about the limitations of assessing flow based solely on the balance between challenges and skills.

The Buffering Effects of Engagement in the Daily Experience of Solitude

In line with previous studies, our findings showed that the psycho-affective experience of solitude of female students was worse, compared to other social contexts (Adam, 2006; Brown, 1992; Csikszentmihalyi, 1997a; Larson, 1990; Matias, et al., 2011; Moneta & Csikszentmihalyi, 1996). Students experienced lower positive affect and greater negative affect; they felt less creative and more fatigued and self-conscious. Solitude was also associated with lower levels of engagement and balance between challenges and skills, compared to other company. Our findings that self-consciousness significantly increased in solitude are in line with results from previous studies (Brown, 1992; Csikszentmihalyi, 1997a; Larson & Lee, 1996; Larson, 1997) that found the role of internal processes that take place in this context: individuals think more about themselves, and restructure their sense of self, away from constraints and demands imposed by other people. These processes are essential in young adults that face new social demands, build a sense of self, and develop personal projects. Consequently, solitude can contribute to increase psychological well-being (Larson,

1997). Our results showed that, in solitude, female students had an overall negative affective experience. However, we cannot ascertain the causal direction of this finding: whether solitude incites negative affect, and decreases positive affect; or whether students who feel sad, lonely, and tired search voluntarily for solitude.

Findings showed that students felt more fatigue alone than with other people. Previous studies showed that individuals experience increases in levels of energy and activation when they are involved in social interactions after being alone (Larson, 1990). Being alone seems to be a context in which individuals experience lower physical and mental activation. The moments of the day in which reports of solitude are more frequent might also explain these findings: early mornings and late afternoons after work/classes. However, in the current study, we controlled effects of time of day on subjective experience, which indicates that time of day was not a confounder of the subjective experience of solitude.

Finally, results showed that, in situations of high engagement, students experienced similar levels of effortless attention and motivation whether they were alone or with other people. Some authors have argued that being alone can also be a positive experience (Csikszentmihalyi, 1984, 1997a; Long & Averill, 2003; Long, et al., 2003; Wang, Averill, & Sundararajan, 2004). Solitude can be used for creative and productive activities, to commune with nature, and to concentrate on issues relevant to the self. It has been associated with increases in perceived control, creativity and concentration. Although current findings showed that the affective experience of solitude in this female sample was not positive, we investigated whether engagement might promote a better affective, cognitive and motivational experience in the context of solitude.

Findings showed that high levels of engagement in solitude were associated with similar levels of creativity, fatigue and motivation, compared to other social contexts. However, low levels of engagement in solitude were associated with higher motivation and fatigue and lower creativity, compared to other social contexts. Being more motivated to participate in activities that do not require full engagement in solitude can be related to the need to recover and replenish physical and mental resources. Although activities of low engagement are not associated with a better cognitive and

affective experience, they may have a fundamental role in the recovery from daily stressors. Participants might experience low levels of engagement in situations in which internal resources are depleted and in contexts that lack opportunities for action and expression. In these situations, students might choose to be involved in activities that do not require full engagement, that offer opportunities to replenish internal resources and that are enjoyable and relaxing, such as watching TV and movies or browsing the Internet.

These findings confirmed the protective effects of being highly engaged in this daily context, although these results did not extend to changes in positive affect, which remained lower in solitude than in other social contexts. Thus, it seems that, in the context of solitude, engagement promotes a more *eudaemonic* experience, in which the individual is involved in experiences he is intrinsically motivated to do, and, therefore, feels more creative and active. These findings also confirm that high engagement does not necessarily promote *hedonic* satisfaction; instead, it seems to be associated with experiences of development and growth of individuals' resources and interests.

Study Activities: Opportunities for Engagement and Growth

Students experienced less positive affect, motivation, self-consciousness, and perceived less skills and control in study activities, compared to other activities; they were also more engaged, perceived higher challenges, and levels of balance between challenges and skills. In addition, study activities were perceived as more important for immediate and future goals, than non-study activities. Findings are in line with other studies that found that study activities are a privileged context for the development of the flow state: they offer structured activities with clear goals and challenges that tend to match acquired skills. However, study activities were also associated with the worst subjective experience: students experienced increases in negative affect, fatigue, and decreases in effortless attention.

Findings showed that participants benefited from experiencing high engagement in study activities: they felt more motivated, perceived greater skills, and experienced greater effortless attention and loss of self-consciousness. This latter finding is in line with previous findings that suggest that individuals experience a merging of action and

awareness in experiences of high engagement (i.e., experiences in which external opportunities and internal resources concurrently exist).

Results also showed that although study was significantly associated with greater challenges and balance than non-study activities, engagement levels were associated with decreases in challenges and balance. In tasks of high engagement, the levels of balance and challenges resembled the levels found in non-study activities; in low engagement, students perceived that challenges and balance were much higher in study, compared to non-study activities. Naturalistic data of this sort do not allow us to firmly infer causality in this relation: do lower challenges and balance enable the experience of high engagement? Or does high engagement create a perception of performance as effortless and, as a consequence, challenges and balance are perceived as more attainable than in other tasks?

Previous studies about workload suggest that facing high challenges frequently, even if these match individual skills, can have deleterious effects on psychological and physiological functioning. Within the flow theory, Csikszentmihalyi (e.g., 2002) proposes that individuals are not able to be constantly in a flow state, a view that is extended by research on the processes of self-regulation of attention. Also, very high challenges can be interpreted as stressful depending on the implications of the task for the achievement of individual goals and personal characteristics. Tasks that are perceived as important can be a source of stress if the individual perceives a possible failure to cope as a threat to self-esteem and self-concept. In particular, college students tend to perceive study activities as highly important for the attainment of their future goals, with implications for their professional and personal lives.

The other possible explanation is that high engagement creates the perception of lower challenges. High engagement involves the mobilization of internal and external resources into the task, which might create the perception of performance as effortless and of challenges being more easily attainable than when engagement is low. Previous studies have shown that motivation, interest and enjoyment play a role in the perception of effortless attention, performance, and effort without distress (vs. effort with distress). Finally, personal characteristics may play an important role in the perception of challenges and balance in study activities, and how these activities are

experienced. Some personality characteristics, such as achievement motivation, and non-autotelic personality, are less likely to be associated with the experience of flow in highly challenging tasks, due to personal interpretations about possible failure, whereas other traits, such as performance motives and the autotelic personality are associated with finding challenging activities highly enjoyable and perceiving challenges as opportunities for growth and learning.

It is important to understand which processes underlie positive experiences in study activities and how we can promote them in the lives of college students. According to the psychological selection theory, individuals tend to repeat positive experiences (*hedonic* and *eudaemonic*) and avoid negative experiences (Massimini & Delle Fave, 2000). The frequent experience of the flow state in productive activities has been associated with high achievement (Nakamura, 1988), professional satisfaction, better performance (Harter, Schmidt, & Hayes, 2002; Lefevre, 1988; Lopez & Calderon, 2011), and an overall better psycho-affective experience in other life contexts (Lefevre, 1988; Nakamura & Csikszentmihalyi, 2002). Study activities represent a fundamental context in the daily life of college students, with implications for their personal and professional future. Therefore, promoting engagement in study activities increases the likelihood that students will voluntarily participate in these activities, enjoy them and, eventually, have a better performance. The cumulative effect of the experience of flow can also permeate other daily life contexts, promote individual resources and resilience, and prevent burnout.

Cortisol and Daily Experience: Associations with Affect and Daily Solitude, but not with Engagement.

In the final section of this study, we investigated the associations between momentary experience, daily solitude, and cortisol. Momentary affective experience was significantly associated with cortisol. Decreases in positive affect and heightened negative affect were associated with increases in momentary cortisol levels. These findings are in line with previous work, which observed significant associations between momentary affective states and cortisol (Adam, 2006; Davydov, Shapiro, Goldstein, & Chicz-DeMet, 2007; Jacobs, et al., 2007; van Eck, et al., 1996). The

association between positive affect and cortisol seemed to be stronger than the association between cortisol and negative affect: when all were introduced as predictors in the same model, negative affect lost its significant association with cortisol. We expect that this finding was related to the low-arousal character of the current NA scale.

Momentary levels of engagement were not associated with salivary cortisol. Previous results on the associations between the flow state, flow components and cortisol have yielded mixed results. In daily life, feeling productive was associated with lower momentary cortisol levels in adult women (Adam, 2005). In laboratory settings *effort without distress* (high challenges and motivation and low distress and effort) was associated with lower cortisol compared with *effort with distress* (Frankenhauser & Lundberg, 1982; Lundberg & Frankenhaeuser, 1980). In contrast, Keller and colleagues (2011) showed in male college students that balanced situations (challenges match skills) were associated with increased cortisol levels, compared to situations in which challenges were lower than skills (boredom). However, cortisol levels were similar in situations in which challenges matched skills (balance) and in situations in which challenges were higher than skills (overload). Although involvement (concentration) was greater in balance than in overload situations, there were no significant differences in levels of positive affect. Gender differences in neuroendocrine activation might explain the divergent results found in the associations between flow and cortisol. Previous studies in this field have used either an all-male sample (Keller et al., 2011) or an all-female sample (Adam, 2005). Earlier studies have reported differences in the response to challenging situations according to gender (Frankenhauser & Lundberg, 1982).

Cortisol levels were significantly higher in solitude than in other social contexts. The strength of association of solitude and cortisol was reduced after the introduction of positive affect and negative affect in the model as predictors. However, the association between solitude and cortisol remained significant, indicating that the mediation by affect was partial. These findings confirm those previously found in a smaller subset of this sample (Matias, et al., 2011) and extend those found in adolescents (Adam, 2006).

Finally, some questions arose related to the influence of personal characteristics on the experience of daily contexts and cortisol activation. In the next chapter we explored whether individual characteristics could explain the differences found in momentary subjective experience and engagement. We also tried to understand whether levels of affectivity and the autotelic personality could explain individual differences in the subjective experience of daily contexts. Finally, we investigated whether the association between solitude and cortisol could be more fully explained by individual differences in the experience of daily solitude.

Chapter 5: Personal Characteristics, Everyday Experience and Cortisol

"I believe that traditional wisdom is incomplete. A composer can have all the talent of Mozart and a passionate desire to succeed, but if he believes he cannot compose music, he will come to nothing. He will not try hard enough. He will give up too soon when the elusive right melody takes too long to materialize."

Martin Seligman

The aim of this chapter was to investigate whether personal characteristics, such as autotelic traits and affectivity, were associated with momentary subjective experience and neuroendocrine function in daily life. Furthermore, we wanted to investigate whether the autotelic personality, positive affectivity and negative affectivity were associated with differences in diurnal patterns of cortisol secretion.

First, we looked at the associations between autotelic personality traits and affectivity. We investigated individual differences in reports of time spent in different social contexts (alone, family, friends) and activities (study, leisure, social activities). Studies on the autotelic personality haven't always found significant differences in the time individuals spend in different daily activities (Adlai-Gail, 1994; Asakawa, 2004). However, the most significant differences emerge in the subjective experience of daily activities. We expected that, regardless of the levels of autotelic personality and affectivity characteristics and the structure of students' days, the experience in daily activities would be significantly different according to more stable characteristics that influence attribution styles and attitudes toward daily contexts. Most of the time in students' lives is pre-imposed by college schedules and this can influence times spent in different activities, especially if starting college has changed daily routines and constrained opportunities to participate in activities that students enjoyed before going to college. However, the flow theory suggests that autotelic students will find meaningful and engaging experiences, regardless of the activity they are involved in (e.g., Csikszentmihalyi, 2002; Nakamura & Csikszentmihalyi, 2002).

Therefore, we expected that personal characteristics would account for differences in daily life experience: autotelic individuals approach challenging situations in which

they can use their skills voluntarily and interpret experiences in a more positive way compared to less autotelic individuals. Positive affectivity is associated with greater resilient and the identification of positive aspects in everyday contexts, whereas negative affectivity has been associated with neuroticism, depression, and heightened affective and neuroendocrine response to negative contexts (e.g., Larsen & Ketelaar, 1991; Rusting & Larsen, 1997; Tugade & Fredrickson, 2004; Zelenski & Larsen, 2000). Hence, we investigated whether there were individual differences in the subjective experience of daily contexts – solitude and study activities – that previous research has shown to be associated with negative affective, cognitive, and motivational experiences and, in the case of solitude, with heightened cortisol levels in some individuals (e.g., Adlai-Gail, 1994; Asakawa, 2004; Matias et al., 2011; Nakamura, 1988).

We observed previously that daily solitude was associated with an overall negative cognitive, affective and motivational experience, and heightened cortisol levels. However, experiencing high engagement in solitude was associated with positive outcomes, such as feeling motivated, creative, and active, whereas low engagement was associated with feeling less motivated and creative, and more fatigue in solitude than with other people. The experiential and physiological response to daily contexts and stressors is influenced by individual differences in stable personal characteristics. Therefore, we investigated whether more personal characteristics could be associated with the psycho-affective and neuroendocrine response to solitude.

The autotelic personality is associated with the tendency to experience higher positive affect and lower negative affect (e.g., Csikszentmihalyi, 2002; Nakamura & Csikszentmihalyi, 2002). Overall positive affectivity has been associated with increased happiness, optimism, and extroversion, and lower affective and neuroendocrine response to negative contexts. In contrast, negative affectivity has been associated with neuroticism, depression, greater cortisol secretion and sensitivity to negative contexts. Therefore, we expected that higher levels of autotelic personality and positive affectivity would be associated with a more positive psycho-affective experience of solitude and lower cortisol, whereas negative affectivity was expected to be associated with a worst cognitive, motivational and affective experience and higher cortisol levels in solitude.

Also, we investigated whether there were individual differences in the subjective experience of study activities. As mentioned earlier, study activities present optimal opportunities for development and for the experience of flow: study activities offer challenges that match individual's acquired skills and that increase gradually, and they have structured goals and offer clear feedback about one's performance. However, these activities were also associated with lower affective and motivational momentary experience. Based on individual differences in attribution styles and meaning-making processes associated with the autotelic personality, we expected that being more autotelic would be associated with a more positive psycho-affective experience in study activities.

Finally, we explored the associations between more stable personal characteristics and neuroendocrine function in daily contexts. We investigated whether the association between solitude and cortisol could be more fully explained by personal differences in affectivity and autotelic characteristics. In addition, we investigated whether personal characteristics were associated with cortisol secretion throughout the day. Previous findings tend to associate positive characteristics (e.g., positive affectivity, optimism) with lower daily cortisol secretion, whereas negative personal characteristics (e.g., neuroticism, negative affectivity) show the opposite pattern (e.g., Steptoe & Wardle, 2005; Pruessner, et al., 2005; Ryff & Singer, 2002). Therefore, we expected that autotelic personality and positive affectivity would be associated with lower cortisol secretion in the morning and throughout the day, whereas negative affectivity would be associated with higher cortisol in the morning and throughout the day.

Personal Characteristics and Everyday Experience

To answer our questions related to differences in daily life experience and personal characteristics, we started by analyzing the associations between the personal characteristics assessed. Table 12 shows the descriptive statistics of our student sample. On average, students spent more time alone than with family and friends. They

also spent more time in study-related activities than in leisure and social-related activities. Overall, participants had above average scores on autotelic personality and meanPA and low scores on negative affectivity.

Table 12 *Descriptive Analyses of the Characteristics of Participants and Time Spent in Different Activities and Company*.

Variables	Min	Max	Mean	SD
Positive affectivity (mPA)	2.59	11.00	6.78	1.52
Negative affectivity (mNA)	.22	8.68	2.73	1.90
Autotelic personality (AP)	3.99	10.18	7.55	1.17
Variations in PA (vPA)	.41	4.50	1.52	.67
Variations in NA (vNA)	.29	2.64	1.30	.52
Time in Company[a] (%):				
Solitude	0	76.90	37.41	13.88
Family	0	60.7	19.73	14.38
Friends	0	51.4	14.65	14.56
Time in Activity[a] (%):				
Study	2.56	52.17	25.92	11.76
Leisure	0	48.5	16.19	9.00
Social interactions	2.70	48.5	17.23	10.06

Notes. Values of positive affectivity, negative affectivity, and autotelic personality range between 0 and 12. Solitude (1=alone), family (1=family), friends (1= friends), study (1= study), leisure (1=leisure), and social activities (1= social) were dummy coded.
vPA - intraindividual standard deviation of momentary PA during the assessment week; vNA - intraindividual standard deviation of momentary NA during the assessment week; SD – between-individidual standard deviation.
[a]Time in different company and activities represents the relative frequency of ESF in which participant reported being in that company and activity during the assessment week.

Autotelic Personality Associations with Trait Characteristics

We analyzed the associations between autotelic personality, meanPA and meanNA. Results showed that AP levels were strongly associated with meanPA (r (65) = .74, p < .001) and meanNA (r (65) = -.66, p < .001); meanPA was moderately associated with meanNA (r (65) = -.54, p < .001). Next, we investigated whether scores on autotelic personality were associated with less variation in PA and NA in daily life. Results

showed that AP was associated with variations in NA (r (65) = -.30, p < .05), but not with variations of PA in daily life (r (65) = .07, p = .57). Also, meanNA was associated with variations in NA (r (65) = .39, p < .001), but not with variations in PA (r (65) = .01, p = .95). Finally, meanPA was not associated with variations in PA (r (65) = -.07, p = .57) and NA (r (65) = -.15, p = .23). Overall, autotelic students tended to have higher meanPA, lower meanNA and experienced less variations in state NA in their everyday lives.

Individual Differences in Everyday Activities and Company

We examined the associations between individual characteristics and daily company and activities reported by students during the assessment week. Autotelic individuals spent more time with family (r (65) = .27, p < .05) than their less autotelic counterparts. However, there were no differences in time spent alone (r (65) = -.04, p = .73) and with friends (r (65) = -.47, p = .71). Also, autotelic and less autotelic students did not differ in the time spent in study (r (65) = -.19, p = .13), leisure (r (65) = .02, p = .87), and social activities (r (65) = .18, p = .15). Students with greater meanPA spent more time with family than students with less meanPA (r (65) = .33, p < .01). However, there were no significant differences in the time reported spent alone (r(65) = -.15, p = .22) and with friends (r (65) = .03, p = .81). MeanPA was not associated with time reported in study (r (65) = -.14, p = .25), leisure (r (65) = .06, p = .61), or social activities (r (65) = .21, p = .09). Finally, high meanNA was associated with spending less time with family (r (65) = -.28, p < .05), but not with time alone (r (65) = .01, p = .97) and with friends (r (65) = .11, p = .37). Students with greater meanNA reported spending less time in social activities (r (65) = -.29, p < .05) than students with low meanNA. MeanNA was not associated with time spent in leisure (r (65) = -.09, p = .46) and study activities (r (65) = .21, p = .09) during the assessment week.

Autotelic Personality and Momentary Subjective Experience

We performed separate multilevel regressions to investigate the associations of the autotelic personality and momentary subjective experience[2]. Results showed (Table 13) that individuals with greater autotelic personality experienced lower negative affect and fatigue, and higher levels of engagement, skills and control (marginal) in daily life contexts than less autotelic students. However, autotelic personality was not associated with creativity, self-consciousness, and perceived importance of the activity, challenges and balance.

Table 13 *Multilevel Estimates of the Fixed Effects of Autotelic Personality (AP) on Momentary Subjective Experience*.

			95% Confidence Interval	
Outcome	*B*	SE	Lower	Upper
Negative affect (NA)	-1.06***	.15	-1.36	-.77
Fatigue	-.95***	.20	-1.32	-.58
Self-consciousness	-.00	.20	-.41	.40
Creativity	.32	.20	-.08	.71
Importance	.10	.20	-.30	.50
Control	.44†	.22	-.00	.87
Challenges	.14	.19	-.23	.50
Skills	.45*	.21	.05	.86
Balance levels	.17	.19	-.21	.55
Engagement levels	.44*	.20	.04	.84

Notes. Separate multilevel models were estimated for each outcome. Models control the effects of Time (centered on the mean of all sampling times - 15:08). Autotelic personality (AP) was centered on the grand mean. Models include 2270 ESM observations measures nested within 67 subjects.
B - unstandardized regression coefficient; SE - standard error.
†$p < .10$. *$p < .05$. **$p < .01$. ***$p < .001$.

[2] Multilevel models estimates for overall experience account for mean outcome level for each individual, therefore we did not include the results of variables that were included in the index of AP (positive affect, effortless attention and motivation), because of high correlation between predictor and outcomes.

Affectivity and Momentary Subjective Experience

We investigated the associations between personal characteristics (meanPA, meanNA and AP) and momentary subjective experience. Results (Table 14) showed that meanNA explained more fully the levels of fatigue than the autotelic personality. Autotelic personality was associated with increased levels of creativity, self-consciousness and engagement. MeanPA was associated with increased motivation, whereas meanNA was associated with increased creativity, self-consciousness and fatigue.

Table 14 *Multilevel Regression Estimates for Fixed Effects of Personal Characteristics on Subjective Experience*.

	B (SE)		
Outcome	AP	meanPA	meanNA
Positive affect (PA)			-.43 (.08)***
Negative affect (NA)	-.91 (.22)***	-.16 (.17)	
Motivation		-.11 (.16)	-.58 (.13)***
Effortless attention		.35 (.12)**	-.11 (.10)
Fatigue	-.26 (.23)	.25 (.16)	.86 (.11)***
Self-consciousness	.66 (.31)*	-.06 (.21)	.57 (.15)***
Creativity	.77 (.32)*	-.02 (.22)	.40 (.16)**
Importance	.00 (.33)	.31 (.23)	-.19 (.16)
Control	.22 (.37)	.06 (.25)	-.14 (.18)
Challenges	.11 (.31)	.21 (.21)	.17 (.15)
Skills	-.21 (.32)	.60 (.22)**	-.07 (.16)
Balance levels	.08 (.32)	.22 (.22)	.16 (.16)
Engagement levels	.83 (.33)*	-.21 (.23)	.17 (.16)

Notes. Separate multilevel models were estimated for each outcome. Models control the effects of Time (centered on the mean of all sampling times - 15:08). Autotelic personality (AP), positive affectivity (meanPA) and negative affectivity (meanNA) were centered on the grand mean. Models include 2270 ESM observations measures nested within 67 subjects.
We did include predictors in the models if the outcome was part of the index measure (e.g., meanPA and PA, meanNA and NA), thus having high collinearity.
B - unstandardized regression coefficient; SE - standard error.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Individual Differences in the Experience of Daily Contexts

We investigated whether high autotelic characteristics, high positive affectivity and low meanNA were associated with more positive subjective experiences in distinct daily life contexts. Do these individual characteristics protect against potential deleterious psychological effects of being alone? Do students who are autotelic and have high positive affectivity and low meanNA use solitude in a more positive way? Do they experience engagement and creativity in situations in which less autotelic students would experience boredom and alienation? How is their experience in study activities? Do they experience more engagement and creativity in study activities? Are study activities less stressful for autotelic students than for less autotelic students?

We followed the steps of moderation models proposed by Baron and Kenny (1986) to investigate possible moderation effects of personal characteristics on the associations between solitude and study activities, and momentary subjective experience.

The Experience of Solitude of Autotelic Students

We used different multilevel models to investigate the associations between personal characteristics and the experience of solitude of female college students. First, we estimated a multilevel model to examine the association of autotelic personality, daily solitude and their interaction on momentary experience. Results (Table 15) showed that autotelic students experienced less NA (marginal) and perceived the activities they were doing as less important for their immediate and future goals.

Post hoc analyses showed that only individuals with low scores on autotelic personality experienced significantly higher NA in solitude than in other company. Students with high autotelic personality scores had similar levels of NA whether they were alone and not alone. Finally, the perception of importance for the individual's goals was significantly different between low and high scores of autotelic personality: students with autotelic personality perceived activities in solitude as less important, whereas less autotelic students perceived activities done in solitude as more important to their goals than activities done in the company of other people.

Table 15 *Multilevel Regression Estimates for the Effects of Autotelic Personality on the Association Between Solitude and Momentary Subjective Experience.*

	B (SE)		
Outcome	Solitude	AP	AP*Solitude
Positive affect (PA)	-.69 (.07)***	.94 (.11)***	-.01 (.06)
Negative affect (NA)	.59 (.06)***	-1.02 (.15)***	-.10 (.05)†
Motivation	-.10 (.19)	1.21 (.16)***	-.11 (.16)
Effortless attention	-.18 (.11)	.86 (.12)***	-.06 (.10)
Fatigue	.57 (.10)***	-.98 (.19)***	.11 (.09)
Self-consciousness	.28 (.14)*	.07 (.21)	-.19 (.12)
Creativity	-.23 (.09)*	.32 (.20)	-.01 (.08)
Importance of activity	-.41 (.15)**	.26 (.21)	-.41 (.14)**
Control	-.04 (.11)	.40 (.23)†	.10 (.09)
Challenges	-1.06 (.14)***	.20 (.19)	-.19 (.12)
Skills	-.29 (.11)**	.44 (.21)*	.02 (.09)
Balance levels	-1.09 (.15)***	.22 (.20)	-.16 (.13)
Engagement levels	-1.00 (.16)***	.50 (.21)*	-.17 (.13)

Notes. Separate multilevel models were estimated for each outcome. Models control the effects of Time (centered on the mean of all sampling times - 15:08). Autotelic personality (AP) was centered on the grand mean. Solitude was dummy coded (1 *alone*). Models include 2270 ESM observations measures nested within 67 subjects.
B - unstandardized regression coefficient; SE - standard error.
†$p < .10$. *$p < .05$. **$p < .01$. ***$p < .001$.

Positive affectivity and the experience of solitude.

Next, we examined the associations between meanPA and the subjective experience of solitude. Results (Table 16) showed that higher meanPA was associated with momentary decreases of NA and perceived challenges (marginal) in solitude compared to other social contexts.

Post hoc analyses revealed that momentary NA was only significantly higher in solitude than in other contexts in individuals with low meanPA; students with high meanPA did not experience different NA levels in solitude and other social contexts. In addition, students with high meanPA perceived significantly lower challenges in

solitude than other social contexts, whereas students with low meanPA perceived the challenges faced in solitude as similar to those faced in other social contexts.

Table 16 *Multilevel Regression Estimates for the Effects of Positive Affectivity on the Association Between Solitude and Subjective Experience.*

	B (SE)		
Outcome	Solitude	meanPA	meanPA*Solitude
Positive affect (PA)	-.67 (.07)***	.97 (.04)***	.02 (.05)
Negative affect (NA)	.59 (.06)***	-.63 (.13)***	-.11 (.04)*
Motivation	-.12 (.19)	.31 (.16)*	-.09 (.12)
Effortless attention	-.17 (.11)	.41 (.11)***	.03 (.07)
Fatigue	.57 (.10)***	-.51 (.16)***	.10 (.07)
Self-consciousness	.28 (.14)*	-.04 (.16)	.08 (.09)
Creativity	-.23 (.09)*	.11 (.16)	.08 (.06)
Importance of activity	-.41 (.16)**	.24 (.16)	-.16 (.10)
Control	-.04 (.11)	.25 (.17)	.09 (.07)
Challenges	-1.06 (.14)***	.21 (.15)	-.17 (.09)†
Skills	-.29 (.11)**	.49 (.15)**	.10 (.07)
Balance levels	-1.09 (.15)***	.22 (.15)	-.15 (.10)
Engagement levels	-1.00 (.16)***	.13 (.16)	-.01 (.10)

Notes. Separate multilevel models were estimated for each outcome. Models control the effects of Time (centered on the mean of all sampling times - 15:08). Positive affectivity (meanPA) was centered on the grand mean. Solitude was dummy coded (1 *alone*). Models include 2270 ESM observations measures nested within 67 subjects.
B - unstandardized regression coefficient; SE - standard error.
†$p < .10$. *$p < .05$. **$p < .01$. ***$p < .001$.

Negative affectivity and the experience of solitude.

We looked at the associations of meanNA and the subjective experience of solitude. Results (Table 17) showed that levels of meanNA were associated with NA, perceived balance, importance of the activity, and perceived challenges.

Post hoc analyses showed that meanNA was associated with significant differences in the perception of balance, challenges and importance of the activity in solitude:

students with greater meanNA perceived similar of levels of balance, challenges and importance of the activity to their goals in activities done in solitude and in other company. However, students with low meanNA perceived that activities done in solitude had lower levels of balanced and challenges and were less important for their goals than activities done in the company of others. Although individuals with high meanNA had significantly higher NA in solitude than individuals with low meanNA, levels of NA were always higher in solitude than in other social contexts.

Table 17 *Multilevel Regression Estimates of the Effects of Negative Affectivity on the Association Between Solitude and Momentary Subjective Experience*.

	B (SE)		
Outcome	Solitude	meanNA	meanNA*Solitude
Positive affect (PA)	-.69 (.07)***	-.45 (.08)***	.05 (.04)
Negative affect (NA)	.58 (.06)***	.95 (.03)***	.09 (.03)***
Motivation	-.12 (.19)	-.51 (.11)***	-.07 (.10)
Effortless attention	-.18 (.11)	-.24 (.09)**	-.04 (.06)
Fatigue	.56 (.10)***	.86 (.09)***	-.03 (.05)
Self-consciousness	.29 (.14)*	.30 (.12)*	.05 (.07)
Creativity	-.23 (.09)*	.10 (.13)	.01 (.05)
Importance	-.40 (.16)**	-.02 (.13)	.19 (.08)*
Control	-.05 (.11)	-.25 (.14)†	-.01 (.05)
Challenges	-1.05 (.14)***	-.06 (.12)	.24 (.07)***
Skills	-.30 (.11)**	-.23 (.13)†	-.05 (.06)
Balance levels	-1.08 (.15)***	-.11 (.12)	.23 (.77)**
Engagement levels	-1.00 (.16)***	-.10 (.13)	.08 (.08)

Notes. Separate multilevel models were estimated for each outcome. Models control the effects of Time (centered on the mean of all sampling times - 15:08). Negative affectivity (meanNA) was centered on the grand mean. Solitude was dummy coded (1 alone). Models include 2270 ESM observations measures nested within 67 subjects.
B - unstandardized regression coefficient; SE - standard error.
†$p < .10$. *$p < .05$. **$p < .01$. ***$p < .001$.

The Experience of Study Activities of Autotelic Students

We used different multilevel models to investigate the associations between personal characteristics and the experience of study activities of students. First, we estimated a multilevel model to investigate the association of autotelic personality and the momentary experience of daily study activities.

Results (Table 18) showed that the autotelic personality was associated with motivation, engagement levels, perceived challenges, and with the perception of balanced experiences (marginal) in study activities.

Table 18 *Multilevel Regression Estimates for the Effects of Autotelic Personality on the Association Between Study Activities and Momentary Subjective Experience*.

	B (SE)		
Outcome	Study	AP	AP*Study
Positive affect (PA)	-.18 (.08)*	.94 (.11)	.01 (.07)
Negative affect (NA)	.09 (.07)	-1.05 (.15)***	-.03 (.06)
Motivation	-2.66 (.20)***	1.04 (.16)***	.35 (.17)*
Effortless attention	-.02 (.13)	.81 (.12)***	.10 (.11)
Fatigue	.05 (.11)	-.91 (.19)***	-.12 (.09)
Self-consciousness	-1.14 (.15)***	-.07 (.21)	.16 (.13)
Creativity	.29 (.10)**	.35 (.20)†	-.09 (.09)
Importance of activity	3.61 (.16)***	.11 (.20)	.21 (.13)
Control	-.37 (.12)**	.39 (.22)†	.14 (.10)
Challenges	2.34 (.15)***	.10 (.18)	.28 (.13)*
Skills	-.52 (.12)***	.47 (.21)*	-.11 (.10)
Balance levels	2.20 (.16)***	.13 (.19)	.26 (.14)†
Engagement levels	1.26 (.17)***	.34 (.20)†	.47 (.15)***

Notes. Separate multilevel models were estimated for each outcome. Models control the effects of Time (centered on the mean of all sampling times - 15:08). Autotelic personality (AP) was centered on the grand mean. Study was dummy coded (1 study). Models include 2270 ESM observations measures nested within 67 subjects.
AP – Autotelic Personality; *B* - unstandardized regression coefficient; SE - standard error.
†$p < .10$. *$p < .05$. **$p < .01$. ***$p < .001$.

Post hoc analyses showed that the levels of motivation in highly autotelic students were not different in study and non-study activities, whereas less autotelic students had lower levels of motivation during study. High autotelic personality levels were associated with the perception of greater balance and challenges in study than in non-study activities, whereas students with low autotelic personality did not perceive differences in challenges and balance in study, compared to non-study activities. Finally, levels of engagement were significantly higher for autotelic students in study activities, compared to non-study activities. However, engagement levels were significantly lower in study activities than other activities in individuals with low autotelic personality scores.

Positive affectivity and the experience of study.

Next, we performed multilevel regression analyses to investigate the effects of meanPA on the associations between daily study activities and momentary subjective experience. Results (Table 19) showed that meanPA was significantly associated with individual differences in creativity, perception of importance of the activity, skills, and marginally with self-consciousness and challenges in study activities.

Post hoc tests revealed that women with high meanPA experienced similar levels of creativity and self-consciousness, and attributed greater importance to study than non-study activities. However, students with low meanPA experienced higher levels of creativity and loss of self-consciousness in study, compared to non-study activities. Low meanPA was not associated with differences in perceived importance of the activity. In addition, students with high meanPA perceived lower skills and greater challenges in study than non-study activities. However, students with low meanPA did not experience any differences in perceived skills and challenges in study, compared to other activities.

Table 19 *Multilevel Regression Estimates for the Effects of Positive Affectivity on the Associations Between Study Activities and Momentary Subjective Experience.*

	B (SE)		
Outcome	Study	meanPA	meanPA*Study
Positive affect (PA)	-.19 (.08)*	.99 (.04)***	-.02 (.05)
Negative affect (NA)	.09 (.07)	-.68 (.13)***	.01 (.04)
Motivation	-2.70 (.20)***	.20 (.15)	.20 (.13)
Effortless attention	-.04 (.13)	.43 (.11)***	-.05 (.08)
Fatigue	.06 (.11)	-.48 (.16)**	-.02 (.07)
Self-consciousness	-1.14 (.15)***	-.12 (.16)	.17 (.10)†
Creativity	.28 (.10)***	.18 (.16)	-.13 (.07)*
Importance	3.63 (.16)***	.14 (.15)	.34 (.10)***
Control	-.39 (.12)***	.29 (.17)†	-.02 (.08)
Challenges	2.34 (.15)***	.14 (.14)	.17 (.10)†
Skills	-.52 (.12)***	.57 (.15)***	-.17 (.08)*
Balance levels	2.20 (.16)***	.18 (.14)	.12 (.10)
Engagement levels	1.23 (.18)***	.12 (.16)	.16 (.11)

Notes. Separate multilevel models were estimated for each outcome. Models control the effects of Time (centered on the mean of all sampling times - 15:08). Positive affectivity (meanPA) was centered on the grand mean. Study was dummy coded (1 *study*). Models include 2270 ESM observations measures nested within 67 subjects.
B - unstandardized regression coefficient; SE - standard error.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Negative affectivity and the experience of study.

Finally, we analyzed the associations of meanNA and the experience of daily study activities. Results (Table 20) showed that meanNA scores were significantly associated with changes in momentary effortless attention, motivation, engagement, perceived control, challenges, and balance levels in study activities, compared to non-study activities.

Post hoc tests showed that students with high meanNA experienced lower effortless attention in study than non-study activities, whereas students with low meanNA experienced higher effortless attention in study than non-study activities.

MeanNA was associated with decreases in momentary motivation, perceived challenges and levels of balance in the experience. Regardless of the score on meanNA, motivation was always lower, and perceived challenges and balance were always greater in study activities. Finally, students with high meanNA levels perceived lower control and effortless attention in study activities than in other activities; however, there were no significant differences between study and non-study activities in the perception of control of students with low meanNA and in the experience of engagement in students with high meanNA.

Table 20 *Multilevel Regression Estimates for the Effects of Negative Affectivity on the Association Between Study Activities and Momentary Subjective Experience*.

	B (SE)		
Outcomes	Study	meanNA	meanNA*Study
Positive affect (PA)	-.18 (.08)*	-.42 (.08)***	-.04 (.04)
Negative affect (NA)	.09 (.06)	.99 (.03)***	.03 (.03)
Motivation	-2.65 (.20)***	-.43 (.11)***	-.25 (.10)*
Effortless attention	.02 (.13)	-.16 (.09)†	-.35 (.06)***
Fatigue	.05 (.11)	.84 (.09)***	.06 (.06)
Self-consciousness	-1.15 (.15)***	.37 (.12)**	-.09 (.08)
Creativity	.30 (.10)**	.11 (.13)	-.04 (.05)
Importance	3.61 (.16)***	.03 (.12)	-.10 (.08)
Control	-.36 (.12)**	-.21 (.14)	-.14 (.06)*
Challenges	2.35 (.15)***	.05 (.11)	-.20 (-.08)*
Skills	-.50 (.12)***	-.23 (.13)†	-.05 (.06)
Balance levels	2.22 (.16)***	.03 (.12)	-.26 (.08)***
Engagement levels	1.30 (.17)***	.03 (.13)	-.43 (.09)***

Notes. Separate multilevel models were estimated for each outcome. Models control the effects of Time (centered on the mean of all sampling times - 15:08). Negative affectivity (meanNA) was centered on the grand mean. Study was dummy coded (1 study). Models include 2270 ESM observations measures nested within 67 subjects.
B - unstandardized regression coefficient; SE - standard error.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Autotelic Personality, Affectivity and Cortisol

First, we estimated multilevel models to investigate the associations between autotelic personality, meanPA, meanNA and momentary cortisol levels. However, results (Table 21) showed that these personality characteristics were not associated with momentary cortisol.

Table 21 *Multilevel Regression Estimates for the Effects of Autotelic Personality, Positive Affectivity and Negative Affectivity on Momentary Cortisol Levels*.

	B (SE)			
	Model 1	Model 2	Model 3	Model 4
Positive affectivity (meanPA)	-.01 (.03)			-.06 (.04)
Negative affectivity (meanNA)		-.02 (.02)		-.02 (.03)
Autotelic personality (AP)			.03 (.04)	.06 (.06)

Notes. Models control for effects of Time (centered on the mean of all sampling times - 15:08). Autotelic personality (AP), positive affectivity (meanPA) and negative affectivity (meanNA) were centered around the grand mean. Models include 2270 ESM observations measures nested within 67 subjects.
B - unstandardized regression coefficient; SE - standard error.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Moderating Effects of Personality on the Solitude-Cortisol Association

Next, we estimated separate multilevel models to investigate whether autotelic personality, meanPA, and meanNA moderated the association between daily solitude and cortisol. Results (Table 22) showed that solitude remained significantly associated with cortisol regardless of personality characteristics. MeanNA was significantly associated with greater cortisol in solitude. There were no moderation effects of AP and meanPA on the association between solitude and cortisol.

Table 22 *Multilevel Regression Estimates for the Moderating Effects of Personal Characteristics on the Association Between Daily Solitude and Momentary Cortisol.*

	B (SE)		
	Model 1	Model 2	Model 3
Intercept	1.33 (.05)***	1.33 (.05)***	1.33 (.05)***
Solitude	.10 (.04)**	.10 (.04)**	.10 (.04)**
Autotelic Personality (AP)	.05 (.04)		
Solitude*AP	-.05 (.03)		
Positive affectivity (meanPA)		.00 (.03)	
Solitude*meanPA		-.03 (.02)	
Negative affectivity (meanNA)			-.04 (.02)
Solitude*meanNA			.05 (.02)*

Notes. Outcome is log-cortisol. Models control for effects of Time (centered on the mean of all sampling times - 15:08). Autotelic Personality (AP), Positive affectivity (meanPA) and Negative affectivity (meanNA) were centered around the grand mean. Models include 2270 ESM observations measures nested within 67 subjects.
B - unstandardized regression coefficient; SE - standard error.
$^{\dagger}p < .10$. $*p < .05$. $**p < .01$. $***p < .001$.

Post hoc analyses showed that individuals with high meanNA showed a heightened cortisol response to solitude, whereas students with low meanNA had similar cortisol levels in solitude and in other social contexts.

CAR and the Autotelic Personality

We investigated whether personality characteristics were associated with cortisol levels at waking and the CAR. Multilevel models used to assess cortisol levels at waking and the CAR had 2 levels: person and day level. The hour of waking was significantly associated with the CAR (B = -.23, SE = .08, $p < .01$), but not with cortisol levels at waking (B = -.08, SE = .06, p = .142). Therefore, hour of waking was kept as a predictor in the model for the CAR.

We estimated separate models for cortisol levels at waking and the CAR. However, none of the personality characteristics was significantly associated with either variable (Table 23).

Table 23 *Regression Estimates for the Personal Characteristics on Cortisol Levels at Waking and CAR*.

	B (SE)	
	Cortisol at waking	CAR
Intercept	2.09 (.61)***	3.40 (1.42)*
Negative affectivity (meanNA)	-.06 (.06)	.13 (.10)
Positive affectivity (meanPA)	-.19 (.10)†	.17 (.18)
Autotelic Personality (AP)	.23 (.16)	-.16 (.29)

Notes. The dependent variable is log-cortisol. Model for CAR controls the effects of time of waking. The model includes 32 daily cortisol and personality measures nested within 16 subjects.
B - unstandardized regression coefficient; SE - standard error.
†$p < .10$. *$p < .05$. **$p < .01$. ***$p < .001$.

Discussion

In line with our expectations, autotelic personality characteristics were associated with trait affectivity, affective stability and positive subjective experiences in daily life. Autotelic students tended to have greater positive affectivity, lower negative affectivity and less variation in negative affect, all of which are indicators of greater well-being and positive functioning. In daily life, autotelic students were more engaged and experienced greater balance in their daily activities, they had more positive affective experiences in solitude and had a better psycho-affective experience in study activities than less autotelic students. The associations between autotelic personality and cortisol were only partly confirmed. Autotelic personality traits were not associated with momentary cortisol levels. In the context of solitude, only negative affectivity was associated with greater cortisol levels in solitude. None of the personality characteristics assessed was associated with cortisol levels at waking and the CAR.

Autotelic Personality and Trait Correlates: Associations with a Better Overall Functioning

In line with our expectations, autotelic women had higher levels of positive affectivity and lower levels of negative affectivity. These findings extend previous results that link autotelic personality to positive psychological traits in adolescents to female college students (Adlai-Gail, 1994; Asakawa, 2010; Csikszentmihalyi, 1993, 1997a; Csikszentmihalyi & Csikszentmihalyi, 1988; Nakamura & Csikszentmihalyi, 2002). Higher positive affectivity and lower negative affectivity are associated with greater well-being and mental and physical functioning (Barak, 2006; Chida & Steptoe, 2008; Clark, Watson, & Mineka, 1994; Csikszentmihalyi & Hunter, 2003; Diener & Biswas-Diener, 2008; Lai, et al., 2005; Lyubomirsky, King, & Diener, 2005; Steptoe, Wardle, & Marmot, 2005; Tugade, Fredrickson, & Barrett, 2004). We found that autotelic students experienced less vNA in daily life, but no significant associations were found for vPA. Similarly, greater negative affectivity, a trait

associated with other personality risk factors of psychopathology (e.g., neuroticism), was associated with greater variation in NA, but not PA. However, meanPA was not associated with either vPA or vNA. We observed that individual vPA were greater than vNA (4.09 vs. 2.35, respectively), however, vPA was not associated with different scores on any of the personality traits assessed. Although we must be cautious when analyzing variables that result from between-individual mean scores (meanNA, meanPA, AP) and person-level standard deviations (vPA and vNA), current findings showed that, unlike what would be statistically expected, greater mean scores did not always predict greater variations in the associated variable (e.g., high meanPA was not associated with high vPA). Furthermore, although the AP index included meanPA levels, we observed that AP was associated with decreased variations in NA, but not PA. This indicates that person-level variations might be a good indicator of individual functioning, although the analyses of person-level variations and personal traits should be restricted to variables that are not highly correlated.

Emotional well-being research shows that individuals tend to rate themselves as moderately happy and joyous (Diener & Diener, 1996; Diener, et al., 1991, 2002; Lucas, Diener, & Larsen, 2003). These ratings might only decrease substantially in adverse contexts and psychopathology. In contrast, negative affect seems to be more volatile in response to daily contexts and seems to be a good measure to assess differences in sensitivity to stress from one individual to the next. For example, psychophysiological well-being was associated with concurrent low negative affectivity and high positive affectivity. In contrast, even if positive affectivity was high, having high negative affectivity was associated with less physical and psychological well-being. Hence, current findings might indicate risk processes for the development of psychopathology in a healthy population of young women.

The findings that autotelic students had lower negative affectivity, higher positive affectivity and lower vNA seem to indicate a better overall functioning and resilience in the face of negative experiences, possibly related to better psychological resources. Overall, these characteristics are in line with those proposed by the broaden-and-build theory of emotions: the experience of positive affect has a cumulative effect on the development of adaptive personal structures and decreased sensitivity to adverse daily contexts (Fredrickson, 2004; Fredrickson & Branigan, 2005; Fredrickson & Joiner,

2002; Fredrickson & Losada, 2005). Research on optimism and positive affectivity shows that individuals with these traits search pro-actively for daily contexts that promote growth and are more sensitive to positive experiences than to negative experiences, whereas researchers have found the opposite pattern in negative affectivity (Larsen & Ketelaar, 1989, 1991; Peterson, 2000; Rusting & Larsen, 1997). Therefore, it is plausible that this psychological and behavioral pattern might also explain differences found between autotelic and less autotelic individuals in daily life experiences, engagement and performance.

Personality Traits and Everyday Life

Previous studies of differences in the way autotelic and non-autotelic students structure their everyday lives – activities they participate in and company they are with – have yielded inconclusive results. However, most studies suggest that autotelic students spend more time in productive activities partly as a result of the more positive experience they have in these contexts (Adlai-Gail, 1994; Asakawa, 2010; Nakamura, 1988). To our knowledge, although some studies find that family structure and interactions play an important role in the development of autotelic characteristics (Nakamura & Csikszentmihalyi, 2002; Rathunde, 1988), our results did not suggest differences in the time autotelic and non-autotelic students spend in different company.

In the current study, we found that there were no differences in the time reported in productive, leisure and social activities during the assessment week. These findings can be related to the time structure imposed by college life. In addition, students might have needed to restructure the time and the kind of activities they participated in when they entered college. Moving from their hometown and time constraints related to classes and traveling can present challenges to the maintenance of previous activities, and create the need to develop a new time-budget that takes into account time for study and leisure. Regardless of how individuals spend their time, we were particularly interested in the experiences in these contexts, which can have important consequences to the development of personal interests and trajectories.

In relation to the company students reported being with during the assessment week, we found significant individual differences between autotelic and less-autotelic

students. The autotelic personality was associated with spending more time with family members. Spending time with family is highly constrained for half of our student sample, which has moved from the parents' home and might visit them only during the weekend. Literature shows that the family is an important context for the development of autotelic and creative individuals. Autotelic families provide challenges and autonomy, but also support and encouragement. These characteristics promote the development of positive personal resources, such as resilience, persistence, and optimism (Csikszentmihalyi, 1996, 1997a; Nakamura & Csikszentmihalyi, 2002; Rathunde, 1988). The autotelic family context plays an important role in personal development and in the expression of autotelic characteristics in young adulthood. However, we cannot be certain of the direction of this association: does being autotelic lead to better family interactions and, as a consequence, autotelic students spend more time with family members? Or does spending time with family provides emotional and psychological support that helps individuals search for and maintain high engagement in daily life, even as they develop their personal and professional trajectories outside of the family context? In the current study we did not control for availability of family and interactions with family members, as it was not part of the main aims of this research project. Therefore, we cannot provide an answer to this interesting question. However, the answer might lie somewhere between the two possibilities, as the interactionist approach suggests. Previous research on the autotelic personality has shown that family availability and positive family interactions are extremely important in the development of autotelic characteristics in children and adolescents (e.g., Csikszentmihalyi, 1993; Nakamura & Csikszentmihalyi, 2002); however, it would also be interesting to investigate the role of family as young adults develop into adulthood.

Trait Characteristics and Subjective Experience: Implications for Adaptive and Maladaptive Psychological Processes

As expected, autotelic students showed more positive momentary experiences in daily life: overall, they experienced greater engagement and felt less fatigue and NA. However, the autotelic personality was not associated with balanced experiences, creativity, self-consciousness, control and the perceived importance of activities. These

findings are in line with our expectations that autotelic women would be happier and experience less sadness, loneliness, and boredom. Autotelic students also were less fatigued. We did not find significant associations between autotelic personality and other components of experience (e.g., balance, creativity, self-consciousness). It is possible that differences in the expression of these components are seen in specific contexts of daily life. For example, although balanced experiences were no different between autotelic and less autotelic students, autotelic students perceived greater balance in productive activities than less autotelic students. This evidences the role of the interaction between personal characteristics and context characteristics in the experience of flow in productive activities.

We hypothesized that positive and negative affectivity could mediate the associations of the autotelic personality and momentary experience. Negative affectivity mediated the association between the autotelic personality and fatigue: students with higher scores on negative affectivity felt more fatigue in their everyday lives. This suggests that the increased physical energy described in autotelic individuals might be related to the low levels of negative affectivity and not necessarily high positive affectivity they exhibit. Negative affectivity and its personality correlates have been associated with increased fatigue, lack of energy and depressive symptoms. Therefore, the promotion of autotelic characteristics might have buffering effects against the development of psychopathology: autotelic characteristics were associated with lower momentary negative affect, sensitivity to negative daily contexts and fatigue. Also, autotelic characteristics promote flexible behavioral and cognitive structures that increase resilience to stress and the ability to maintain order in consciousness and avoid disruptive processes, such as depressive rumination, associated with anxiety and depression. These results also seem to indicate that, although the autotelic personality measure includes positive affectivity, it seems to assess characteristics of everyday life and experience that go beyond the more affective characteristics of personality. This relative independence between more *positive affective* and *cognitive* components of personality was previously described in studies of trait absorption and extraversion (Wild et al., 1995) and suggests that further research into these personal characteristics might be needed to fully understand their expression in daily life experience and personal and physiological function.

Findings showed that the autotelic personality and negative affectivity were associated with increased creativity and self-consciousness. Finding that students with high negative affectivity felt more creative seems to be in line with stereotypes of tormented artists and creative geniuses. However, research has shown that although in some cases creative individuals have adverse life contexts in their lives, they often find supportive figures and mentors that help them use their energy in creative and productive ways (Csikszentmihalyi, 1996). Moreover, individuals who excel in several fields, from the arts to science and sports, self-actualized individuals whose creations contribute to their development and the development of societies and cultures are not always tormented (e.g., Csikszentmihalyi, 1996). In fact, they seem to *"have a deep feeling of identification, sympathy, and affection for human beings in general. They feel kinship and connection, as if all people were members of a single family."* (Maslow & Frager, 1987) The finding that these two antagonistic personality characteristics share these momentary experiences is not entirely antithetical. We hypothesize that what distinguishes individuals with high negative affectivity from those with high autotelic personality is their use of the creative drive, i.e., feeling creative does not necessarily lead to creative productions. For example, maladaptive perfectionism can lead to feelings of frustration and have adverse effects on mental health as individuals become incapable of creating something that meets their expectations (Csikszentmihalyi & Csikszentmihalyi, 1988). On the other hand, individuals with "*fear of failure*" do not begin tasks in which they use their creative energy, because they fear they will fail and that threatens their sense of self-competence (Blackwell, et al., 2007; Dweck & Leggett, 1988; Elliot & Harackiewicz, 1996; Elliott & Dweck, 1988; Engeser & Rheinberg, 2008; Grant & Dweck, 2003). In both cases, negative affect can hinder the productive use of creativity. However, positive affect, motivation, focusing attentional resources, and a global view of experiences as opportunities to learn and grow promote feelings of creativity and approach behaviors toward activities in which these feelings can be harnessed.

We found that there was higher self-consciousness in high negative affectivity and autotelic personality. Previous research shows that experts and creative individuals pay attention to their performance and adjust behavioral strategies and characteristics of the tasks to maximize performance and enjoyment (Csikszentmihalyi, 1996; Nakamura

& Csikszentmihalyi, 2001). This perception comes from self-conscious and evaluative processes linked to their personal resources and behavioral and cognitive capacities. In contrast, negative affectivity and its correlates are linked to increased self-consciousness associated with negative evaluative processes, such as rumination, doubt, and worry about other people's perceptions of the self and one's performance. Hence, although participants reported increases in self-consciousness, we could not determine whether this self-reflective process refers to adaptive or maladaptive processes.

Buffering effects of the Autotelic Personality on the Affective Experience of Solitude

In Chapter 4 we found that daily solitude was associated with a negative psycho-affective experience and higher cortisol levels, compared to other social contexts. In the current chapter, we investigated whether the experience of solitude was moderated by personal characteristics. In line with our expectations, autotelic students did not experience increases in negative affect in solitude, compared to other social contexts, whereas less autotelic students did. Hence, it seems that daily solitude is an adverse context to women with less autotelic characteristics. We also found that autotelic women perceived the activities done in solitude as less important than those done in other company, whereas less autotelic women showed the reverse pattern. The results found for affectivity parallel those of the autotelic personality: high positive affectivity was not associated with differences in NA in solitude (vs. other social contexts) and negative affectivity was associated with increases in NA in solitude. However, we observed that negative affectivity was also associated with increased perception of balance, challenges and importance of the activity.

Due to a small sample size, we cannot determine whether autotelic and less autotelic students, and students with high and low negative affectivity are involved in different activities while alone. However, the activities done in solitude are self-determined and students are free to choose activities that they find enjoyable and rewarding. Therefore, differences in the kind of activities autotelic and less autotelic students choose to participate in would be seen in this context. It is also possible that

students with high autotelic scores and low negative affectivity misrepresent the kind of activities done while alone. In a state of intense engagement, students may not hear the beep and may miss reporting what they were doing, or they may report what they were doing with too much delay.

Overall, we observed that the autotelic personality and affectivity have influence on the affective experience of daily solitude. These findings have important implications in the way individuals use this context: low negative affect and high positive affect create ideal conditions for high engagement and broaden one's cognitive and behavioral repertoire. The positive experience of solitude can turn being alone into a positive and productive context for personal and professional development, as seen in previous studies about positive solitude.

Study Activities: Privileged Contexts of Development for Autotelic Students

In line with our expectations, autotelic students had more positive experiences in study activities than less autotelic students: they were more motivated, engaged, and perceived higher balance and challenges in study than non-study activities. Autotelic students in our sample took advantage of the opportunities and structure provided by study activities, making this a privileged context for the development of mental resources. Women with less autotelic characteristics experienced lower motivation, engagement, and perceived less balance in study activities. These findings show that the work paradox pattern seemed to depend on more stable personal characteristics in this all-female sample: less autotelic women experienced lack of motivation and engagement in challenging contexts, although they failed to perceive study activities as being as highly balanced as autotelic women did. Previous studies showed that personality characteristics, such as action-orientation and achievement motives, could determine whether individuals experience high engagement in the face of situations of balance between high challenges and skills (Blackwell, et al., 2007; Dweck & Leggett, 1988; Elliot & Harackiewicz, 1996; Elliott & Dweck, 1988; Engeser & Rheinberg, 2008; Grant & Dweck, 2003). For example, a study of adolescents showed that non-autotelic students experienced more anxiety and less motivation and engagement in flow states (Adlai-Gail, 1994). Our findings extend previous findings of significant

associations between high autotelic personality and increases in the experience of balance, motivation and enjoyment in adolescents to young adults.

We found significant differences in perceived balance and challenges in study activities: autotelic students perceived study activities as more balanced and challenging than non-study activities, whereas less autotelic students perceived that study activities were as balanced as non-study activities. This result suggests that there are inter-individual differences in the perception of challenges and skills. Our findings showed that less autotelic students perceive study activities (vs. non-study) as less balanced and challenging than autotelic students. According to Csikszentmihalyi (Csikszentmihalyi, 1993, 1996, 1997a; Nakamura & Csikszentmihalyi, 2002), autotelic individuals search for challenging situations in their daily lives and create opportunities for action and expression even in routine tasks. This capacity enables them to perceive study activities as more challenging, whereas individuals without these characteristics interpret them either as over-challenging or boring. In a previous study with adolescents (Matias & Freire, 2009), we observed that there were significant differences in the way individuals perceive flow and how it starts: autotelic individuals relied on internal processes and non-autotelic adolescents relied on external cues to experience flow. The current results in young adults extend the findings of personal differences in the experience of flow to the experience of study activities and to the perception of available challenges and balance in these activities. These interpretations have important implications for processes of sustained effort, motivation, performance, investment and permanence in college and scholarly activities. Furthermore, it raises important questions about the predisposition for autotelic individuals to search for challenging activities and about internal attribution processes that contribute to actively interpret daily activities as more challenging. College study activities often involve passive tasks over which students have little control, such as listening to lectures. However, in the current study, autotelic students perceived study activities as much more balanced and challenging. This indicates possible attribution processes that make autotelic students more sensitive to opportunities for action, expression and growth in study activities. The spontaneous identification of challenges in study activities can partly explain the higher

engagement and increased performance in study activities observed in autotelic and talented individuals (Adlai-Gail, 1994; Asakawa, 2010; Nakamura, 1988).

Finally, we found that levels of positive and negative affectivity were significantly associated with differences in the experience of study activities. Women with high positive affectivity perceived that study and non-study activities had similar levels of creativity and self-consciousness, they perceived study activities were more important to their goals and offered greater challenges than non-study activities. They also perceived that their skills were lower in study, compared to non-study activities. In contrast, women with low positive affectivity felt more creative and self-conscious in study activities, but perceived these activities as equally important and challenging as non-study activities. Similarly, women with high negative affectivity experienced lower effortless attention, control, engagement, and perceived study as less balanced and challenging than non-study activities, whereas women with low negative affectivity experienced higher effortless attention and perceived activities as more challenging and balanced than non-study activities; levels of control and engagement were similar in study and non-study activities.

Regardless of negative affectivity scores, levels of perceived balance and motivation were lower in study than non-study activities. These findings confirmed that individuals who had higher positive affectivity, lower negative affectivity, and more autotelic characteristics benefited from productive, challenging and structured activities, such as those found in study. Furthermore, the differences in the subjective experience presented by these different personality characteristics showed that these variables presented different personality constructs that, although related to each other, expressed distinct functioning in daily life experience.

Associations Between Personality and Salivary Cortisol

Finally, we investigated the associations between personality characteristics and cortisol. Although, autotelic personality, positive affectivity and negative affectivity were not associated with overall cortisol levels, there were significant associations according to the social context.

Cortisol and solitude: moderating effects of negative affectivity.

Results confirmed that the effects of solitude on cortisol varied from one person to the next, in relation to more stable personal characteristics. In particular, negative affectivity was associated with higher cortisol levels in the context of solitude, compared to other social contexts, whereas the autotelic personality and positive affectivity were not. Although trait affectivity and the autotelic personality play important roles in shaping the subjective experience of solitude, it seems that only negative affectivity was associated with changes in cortisol levels in this daily context. Previously, we observed that the autotelic personality and positive affectivity were associated with decreases in NA in solitude; however, greater levels of these traits were associated with similar NA when alone and not alone. In contrast, negative affectivity was highly associated with increased NA in solitude, regardless of the score on negative affectivity. Thus, it seems that negative affectivity is a better predictor of affective and endocrine sensitivity to the solitude context than more positive personality traits.

The CAR and trait characteristics.

Contrary to our expectations, the CAR and cortisol levels at waking were not associated with personality traits, except for a marginal association between positive affectivity and lower cortisol at waking. Previous research showed that a small number of people do not show a positive CAR, regardless of compliance to protocol (Dockray, et al., 2008). However, the CAR and cortisol levels at waking are highly dependent on participants' compliance to protocol's sampling times (Dockray, et al., 2008; Kudielka, et al., 2003; Kudielka, et al., 2007). In the current study, we did not have electronic monitoring of participants' compliance to morning samples, which is a limitation. Hence, to reduce bias effects from non-compliance we included only individuals that provided valid saliva samples, gathered between 30-50 minutes after reported waking hour and if there was no decline between the sample after awakening and the second sample, which substantially reduced the final sample size for this analysis. The final

sample size for these analyses was very small, which may explain the lack of significant findings. Therefore, we suggest the use of electronic monitoring of morning saliva samples in studies interested in the study of the CAR.

General Discussion

General Discussion

The main aim of this research project was to understand how positive experiences, such as flow, and personal characteristics contribute to optimal mental and physical function in daily life. We established our framework within the field of positive social science, which recognizes that there is potential for growth in both positive and negative contexts of everyday life depending on how individuals interpret and integrate experiences. The perceptions of individuals about themselves, the world and contextual opportunities guide their choices with greater strength than the objective characteristics of daily contexts. Also, although some situations are associated with similar psychophysiological responses, most daily contexts elicit different responses that result from the interaction between context and individual characteristics and perceptions.

The psychological selection theory proposes that individuals repeat or avoid experiences and contexts based on the quality of their subjective experience. Negative experiences, such as unattainable challenges and lack of adequate physical and psychological resources, create anxiety and reduce the sense of self-efficacy. Chronic and repeated exposure to negative and stressful contexts is associated with the development of mental and physical pathology. On the contrary, positive experiences promote the development of personal resources and skills and are associated with feelings of strength and satisfaction. In the long term, positive experiences and emotions have a cumulative effect on the development of psychological resources and contribute to the enhancement of well-being and personal and professional success. In turn, people focus their attentional resources on information relevant to their development and replicate and change information within their cultural environment (*niche*), if they perceive it as relevant for their adaptation and well-being. One of the experiences that has an important impact in the way people choose their goals and develop their *life theme* is the flow state.

The flow state has been associated with better quality of subjective experience and increased emotional well-being in other daily experiences. The cumulative effects of experiencing flow in daily life can be studied in individuals that present high autotelic

characteristics. Csikszentmihalyi and colleagues (1993, 1996, 1997, 2002; Csikszentmihalyi & Csikszentmihalyi, 1988; Nakamura & Csikszentmihalyi, 2002; Rathunde, 1988) proposed that the autotelic characteristics result from the interaction of genetic predispositions and opportunities from the environment. This interaction promotes the development of skills, attentional resources and emotional regulation that enable individuals to experience flow more easily than individuals without these characteristics. However, the autotelic personality has not been widely studied, especially in relation to its physiological correlates. Studying the associations between the neuroendocrine function and psychological variables is important to understand which processes indicate biological vulnerability to psychopathology. Also, it sheds light into processes associated with resilience, toughness and adaptive mental and physiological response to stress. In sum, it offers clues about physiological processes implicated in better mental and physical health and longevity. Therefore, in the current research we investigated the effects of the flow state (i.e., engagement) and flow propensity (i.e., autotelic personality) on psychological and neuroendocrine function in daily life.

We investigated the daily life experiences and contexts of female college students with the Experience Sampling Method. The ESM allowed us to take a closer look at daily contexts - solitude and productive activities - that are seldom experienced as rewarding and enjoyable by adolescents, young adults, and adults. The inclusion of physiological ambulatory measures allowed us to investigate the physiological correlates of daily life experience and contexts, and further the knowledge about the psychophysiology of the flow state and the autotelic personality. We observed that engagement was beneficial to the subjective experience in these contexts, regardless of personality characteristics; however, we did not find associations between engagement and momentary cortisol. In addition, the autotelic personality and positive affectivity seemed to buffer detrimental effects of daily contexts on subjective experience, whereas negative affectivity heightened the adverse effects of these contexts on subjective experience and neuroendocrine response. Next, we discuss the main findings in our research and the implications for the flow theory, flow assessment and preventive programs aimed at college students.

Engagement: convergence of internal resources, interest, and external opportunities

In the theoretical background chapter we discussed some of the limitations of measuring the flow state using only the balance between challenges and skills. Previous research has shown that optimal experiences (i.e., high balanced experiences) are associated with a better quality of subjective experience in adolescents, adults and the elderly, in normative and psychopathological populations (Carli, Delle Fave, & Massimini, 1988; Delle Fave & Massimini, 2003; Delle Fave, Massimini, & Bassi, 2011; Freire, 2006, 2011; Lima & Freire, 2009). The assessment of optimal experiences with the use of two items is a statistically elegant formulation, especially attending to the high correlations between ESM items. However, balanced experiences do not always ensure that they assess an experience of flow as described in earlier literature and retrospectively: an autotelic experience of high physical and mental engagement, "*one of the best*" experiences in life. Given the aims of the current study, it made sense to create a variable that could integrate both external and internal characteristics of this idiosyncratic experience to investigate its physiological correlates. Therefore, we created the index of autotelicity based on the intensity of two components – effortless attention and motivation – that have a key role in the experience of flow and that could be included with the index of balance to assess engagement levels.

Previous research (Csikszentmihalyi, 2002; Delle Fave, et al., 2011; Lima & Freire, 2009) shows that balanced experiences tend to be associated with lower motivation and enjoyment, particularly in the context of productive activities (i.e., work paradox). Current results extend the findings of lower motivation in contexts of study to the overall momentary experience in female college students. Without motivation and intense involvement, challenging contexts can be sources of stress, especially if stakes are high and if individuals are more sensitive to demanding situations (e.g., non-autotelic, "*fear of failure*" motives, entity theorists, perfectionists). Balanced experiences that are not accompanied by enjoyment and motivation will not be repeated or interpreted as opportunities of flow. This has long-term impact on the development of personal and professional trajectories. However, we also observed that the balance between challenges and skills represents an important component of the

flow experience that assures that we assess an experience of full mental and physical activation.

The levels of autotelicity were associated with increased creativity, motivation, effortless attention, positive affect and reduced negative affect and fatigue. However, autotelicity levels were also associated with increased self-consciousness and lower perception of challenges. These findings suggest that students participate in activities that, although autotelic and cognitively engaging, do not require the full mobilization of physical and mental resources. Drawing a parallel with the flow model and the EFM, it seems that high autotelicity levels would be associated with experiences of relaxation and control, respectively. These experiences have a fundamental role in the maintenance of physical and mental well-being by helping replenish psychic and physiological resources (Csikszentmihalyi, 1997; Csikszentmihalyi & Csikszentmihalyi, 1988; Hawkley, et al., 2005). Moreover, experiences of high autotelicity don't require full engagement and allow attention to wonder toward the self, increasing self-consciousness, and reducing the capacity to "*lose oneself*" in the task. Unlike self-focused ruminative processes, self-conscious processes associated with autotelicity seem to promote a positive subjective experience. This suggests that students that experience high autotelicity are able to think about themselves and their performances in an adaptive manner. Furthermore, these might represent opportunities to explore one's identity and capacities. Other studies showed that the ability to think about the self and personal goals in a flexible and optimistic way is associated with increased psychological well-being and satisfaction with personal and professional domains (Takano & Tanno; Tugade, Fredrickson, & Barrett, 2004; Wild, Kuiken, & Schopflocher, 1995).

Finally, our findings showed that the synergetic interaction between balance levels and autotelicity levels explained more fully the state of high engagement in daily life. Engagement is associated with higher positive affect, creativity, control, and lower negative affect. This index seems to assess rare experiences of high engagement: it takes into account that experiences in daily life are often balanced or autotelic, but seldom both. The measure of engagement allowed us to investigate the associations of the flow state with physiological function in everyday life without confusing flow with experiences of "relaxation" and "threat". Furthermore, we believe that the longitudinal

study of engaging experiences in daily life and the inclusion of global measures to assess internal attributions can shed important clues into the process of psychological selection: what are its manifestations in daily life and which are the internal processes inherent to personal development. The continuous variable of engagement offers several advantages in the study of flow: it combines internal and external components of experience that allows us to investigate the associations with physiological markers; it provides a continuous level of intensity of engagement in daily life, which is more sensitive to intra- and inter-individual variations; it avoids standardization at the individual and group levels. We tested the usefulness of the engagement measure on overall momentary experience, daily contexts, and neuroendocrine response.

Autotelic personality: personal correlates and cortisol

In line with our expectations, autotelic students tended to have higher positive affectivity and lower negative affectivity. Positive affectivity has been associated with traits such as extroversion and openness to experience, whereas negative affectivity is associated with neuroticism, introversion, and depression. High positive affectivity and low negative affectivity are associated with a better psychological functioning and healthier cardiovascular, neuroendocrine and immune function. In addition, we found that autotelic students experienced lower variations in negative affect during the assessment week and students with high negative affectivity showed the opposite pattern. Scores on positive affectivity were not associated with variations in negative and positive affect, although positive affectivity was a component of the autotelic personality measure.

Based on our findings, it seems that the autotelic personality measure assesses characteristics that go beyond the propensity to experience positive affect in daily life. In fact, throughout our study we found that the autotelic personality is relatively distinct from positive and negative affectivity in its associations with subjective and neuroendocrine function. In the study of trait absorption, Wild and colleagues (1995) mention that absorption is associated with a positive cognitive, motivational and affective function, however it is relatively independent of traits such as extroversion, neuroticism, and anxiety. We suggest that the autotelic personality and trait absorption

share important characteristics that are of interest for future research. In particular, it might be important to know the extent to which these different constructs overlap and investigate the associations with other components of personality and how they are expressed in daily life, lifestyles and mental and physical functioning.

Although autotelic personality and negative affectivity were associated with variations in negative affect, none predicted variations in positive affect. These findings may be explained based in the relatively independent nature of positive and negative affect. Previous studies indicate that positive affect has a pattern associated with time of day, day of the week, physical activation and specific daily contexts; whereas negative affect fluctuates throughout the day more freely and usually in response to stressful contexts (e.g., Watson & Pennebaker, 1989). In the present research, we estimated effects of time on subjective experience in preliminary models. We observed that positive affect and negative affect showed a daily circadian pattern: positive affect increased in the morning and decreased throughout the day, whereas negative affect showed the opposite pattern. However, we also observed that the strength of association between time of day and negative affect was weaker than the association between time of day and positive affect. This weaker association is a possible indicator of confounding effects of daily contexts and individual perceptions in the daily fluctuation of negative affect. In addition, all the variables used in our study were significantly associated with times of day. These variations might be associated with the circadian patterns in the case of positive affect, negative affect, and fatigue, as suggested by previous authors (e.g., Kahneman & Krueger, 2004; Watson & Pennebaker, 1989). However, the gradual decline in other variables such as perceived challenges, importance of activity and balance might reflect the structure of daily activities as students go about their daily lives.

People report experiencing positive affect frequently and with greater intensity than negative affect; the latter is often experienced in response to specific stressful contexts (Diener & Ryan, 2009; Kahneman & Krueger, 2006). In addition, certain positive characteristics such as positive affectivity and resilience are associated with protective effects over stressful contexts that influence not only the response to stress, but also its intensity and recovery. Other characteristics such as neuroticism, low resilience, negative affectivity and depressive symptoms are associated with lower

sensitivity to rewards and heightened sensitivity to stress, which increases their affective and physiological response to stressful contexts (Southwick, Vythilingam, & Charney, 2005; Tugade & Fredrickson, 2004; Wichers, et al., 2009; Zelenski & Larsen, 2000). Therefore, the overall positive emotionality that autotelic individuals experience seems to result in greater levels of positive affect and the reduction in intensity, frequency and fluctuations of negative affect. In sum, autotelic individuals seem to have lower reactivity to stress in daily life and a more positive affective experience overall. However, autotelic personality was not associated with either momentary cortisol, or the CAR.

Daily experience: the benefits of engagement and the effects of personal characteristics

Momentary engagement was associated with greater positive affect and lower negative affect, increased motivation and effortless attention, greater creativity and perceived control, and less fatigue in daily life. Contrary to our hypothesis, engagement was not associated with momentary cortisol levels.

Stable personal characteristics were associated with differences in subjective experience. Our results indicated that autotelic students were more often involved in activities that they perceived as having more control over, in which they desired to be and in which they felt creative, happy and engaged. These findings are in line with theoretical assumptions that autotelic individuals are more energetic, have an overall positive emotionality and tend to be involved in activities in which they can experience high engagement (e.g., Nakamura & Csikszentmihalyi, 2002). They perceive greater control over themselves, their emotional experience and their environment, which are characteristics of self-actualized individuals. Also, these findings suggest that autotelic students might derive a more positive meaning from daily activities. Research on individuals with high absorption, resilience and high achievers has shown that these individuals tend to reinterpret instrumental goals as personal and intrinsic (Southwick, et al., 2005; Tugade, et al., 2004; Wild, et al., 1995). Restructuring opportunities and demands to increase intrinsic motivation can lead to greater engagement and, consequently, improved performance.

In daily life, autotelic students were also involved in more self-conscious processes. Autotelic students' enhanced sense of control suggests that they engage in more concrete self-focused thinking instead of a more abstract thinking that is associated with rumination and low sense of mastery. Self-conscious processes can be positive or negative to the individual depending on its focus and direction. Depressive rumination is associated with the development of psychopathology, whereas introspection that is concrete and situational specific can have a more positive valence if aimed at the improvement and adaptation of strategies to improve well-being and performance. Moreover, positive self-consciousness is associated with low levels of boredom proneness (Seib & Vodanovich, 1998), a trait associated with low autotelic personality. In addition, creative individuals and experts report spending time thinking about themselves, their goals, and their performance. A parallel can be drawn between creative, autotelic individuals and individuals with high need for cognition (Cacioppo & Petty, 1982; Cacioppo, Petty, & Kao, 1984; Cacioppo, Petty, & Morris, 1983; Smith & Levin, 1996): all spend more time in decision-making processes and enjoy thinking about complex problems and themselves. Although we have no way to be certain in the current study, we expect that autotelic students would engage in self-conscious processes similar to those described by creative individuals based on the positive valence of their overall experience.

Although results on momentary experience offer important clues about the differences in the psychological functioning between students in our sample, we expected that stable personal characteristics would also be associated with differences in the experiences of distinct contexts of college students' daily life. In this sense, interactions between personal characteristics and daily contexts, which created a clearer picture of the everyday lives of autotelic students.

Previous studies of the psychophysiology of flow yielded contradictory results. The study of male college students by Keller and colleagues (2011) assessed the balance between challenges and skills in an involving activity (playing *Tetris*) and found increases in cortisol levels. However, these levels were similar to those found in the state of overload in which involvement was low and no differences in positive affect were found. Other studies with *effort without distress* showed reduced reactivity of cortisol in comparison with *effort with distress*, especially in women (Frankenhauser

& Lundberg, 1982; Lundberg & Frankenhauser, 1980). Studies of gender differences show that women seem to have lower cortisol reactivity than men. For example, women show lower cortisol reactivity to laboratory stressors and respond to increases in cortisol with a poorer performance, whereas men show better performances when cortisol levels increase (McCormick, et al., 2007). The inclusion of male college students would thus allow us to investigate whether the neuroendocrine response to engagement is influenced by gender. However, the lack of significant associations between engagement and cortisol might also be related to the nature of the activities that students participated in during the assessment week.

Activities such as mountain climbing and running are associated with high engagement and strong physiological responses. However, the activities participants were involved in during the assessment week were mostly passive activities, such as attending lectures, doing homework, reading, writing, and watching TV. Activities reported by participants in this research might not be intense enough to elicit a strong neuroendocrine response. In line with previous findings, we found that affect was associated with momentary cortisol. This suggests that although engagement is a highly enjoyable experience, it is not necessarily associated with cortisol in the everyday life of female college students. The inclusion of event-contingent sampling to the signal-contingent protocol would allow the investigation of intense experiences that elicit stronger engagement and physiological responses (e.g., competitive situations, oral presentations) and that might be otherwise missed using only a signal-contingent protocol.

Perceived importance, balance and challenges: how do daily contexts and engagement influence individual perception?

We observed that the protective effects of engagement on subjective experience were independent of individual characteristics. In solitude, highly engaged students experienced similar levels of positive affect, creativity, control, motivation and fatigue, whereas less engaged students experienced significant decreases in these variables, compared to other social contexts. Although engagement was not associated with changes in perceived challenges and skills in solitude, being highly engaged was

associated with perceiving greater balance between challenges and skills. This latter finding suggests that perceived challenges and skills varied in the solitude context, however the experience of engagement only occurs when there is a concurrent increase of challenges and skills. In study activities, engagement was associated with greater motivation, effortless attention, perceived skills, and loss of self-consciousness; however, it was also associated with decreases in the perception of challenges and balance levels.

The seemingly paradoxical finding that increases in balance are associated with increases of engagement in solitude, but decreases in study activities is understood if we look at the levels of balance in these different contexts: solitude is associated with lower challenges, skills and balance compared to other social contexts, whereas study activities are associated with higher challenges and balance, and lower skills than other activities. Moreover, study activities are perceived as more important to individuals' goals than other activities, but activities done in solitude are usually perceived as less important than activities done with other people. Previous authors have shown that the importance given to activities can be as important in the prediction of a flow state as the existence of balance between high challenges and skills. High challenges, even if matched by adequate skills can be appraised as threats if activities are important to individual's life goals. In this sense, activities done in solitude seem to be less demanding and threatening to the self; therefore, engagement unfolds from higher balanced experiences that occur in this context. In contrast, study activities offer very high challenges in comparison with other activities. If these challenges are perceived as unattainable, they can undermine one's sense of self-competency and have consequences on decisions about future goals.

Another possible explanation is that the experience of engagement makes demands feel more attainable and individuals rate these activities as less challenging. For example, in a study of trait resilience, researchers observed that if participants were primed to perceive tasks as challenges (vs. threat) they experienced less negative affect, regardless of resilience levels (Tugade & Fredrickson, 2004). Engagement seems to replicate this attribution process and lead to a decrease in perceived demands, regardless of personality characteristics. However, we also observed that there were

significant differences in the experience of engagement according to levels of autotelic personality, negative affectivity and positive affectivity.

Engagement and personality in the context of solitude.

In line with previous studies, solitude was associated with greater negative affect and low self-consciousness and fatigue. Engagement in this context seems to promote a more positive subjective experience in which affect, creativity, fatigue, control and motivation are similar to those in other social contexts. Therefore, experiencing engagement seems to bring order into consciousness and increase the likelihood that individuals will use this context for creative and productive activities. The positive experience of solitude has an important role on the development of individual's identity, personal and professional goals: individuals find a space in which to build a coherent sense of self without the demands and constraints of other people. In adolescents, the capacity to be alone is valuable in the development of personal identity and recovery of physical and mental resources. We propose that the experience of solitude can have an important role in exploration processes that unfold during emerging adulthood (Arnett, 2000, 2007b, 2008): emerging adults explore different roles, relations, career paths and develop their professional and personal trajectories with greater independence and self-determination than in adolescence. Although novelties and explorations in this period of life are met with excitement and enthusiasm, they are also met with anxiety and uncertainty that can lead to the development of anxiety and depression symptoms. Therefore, solitude might represent an important context during this stage and in the process of adaptation to college in which students restructure personal goals and think about dilemmas related to their personal, professional and social lives.

Furthermore, sensitivity to the context of solitude is different from one person to the next. Students with high autotelic characteristics and positive affectivity and low negative affectivity did not experience heightened negative affect in this context in comparison to other social contexts, whereas the opposite pattern was found for students with low autotelic characteristics, positive affectivity and high negative affectivity. Autotelic individuals seemed to regulate their emotional experience in the

absence of others more efficiently than less autotelic students. Previous studies (e.g., Asakawa, 2010) showed that the autotelic personality is associated with better emotional regulation and it is associated with the capacity to use this experience to engage in creative and productive activities such as painting, writing, sailing, or communing with nature. Solitude offers the opportunity to roam into the realm of fantasy, to think about what would sound "silly and outrageous" to others and to be completely engaged in the activity without worrying about what others will think or demand. In addition, autotelic students also seem to have an overall positive emotionality that broadens their abilities to find positive meanings in daily life contexts and recognize opportunities in situations that others may not.

Students with autotelic personality, positive affectivity and low negative affectivity also seem to interpret activities done in solitude as less important, challenging and balanced than those done outside this context. A possible interpretation for these findings relates to the characteristics of our sample. College students have built their professional goals around study activities. In solitude, students reported being in study activities 22% of times and they spent most of their time alone in activities such as leisure (26%), maintenance (25%) and rest (14%). These activities might not be interpreted as being as important as those done in the context of study. The experience of autotelic students in study activities showed us that they enjoyed participating in study activities, whereas less autotelic students did not. Autotelic students, like individuals with high trait absorption, have a greater knowledge about themselves, their internal states and emotions. These skills allow them to regulate their emotions and behaviors better than individuals that do not have such an intrinsic knowledge about their own rhythms, emotions, and cognitive functioning. Therefore, autotelic students might use this context to restore their physical and mental resources, so that they are ready to engage fully in tasks that are interesting and relevant for their own interests and future goals.

The associations between personal characteristics, daily solitude and cortisol partly replicated findings observed in a smaller subset of this sample: solitude was associated with increases in cortisol in solitude, in comparison with other social contexts. Also, the association between solitude and cortisol was partly moderated by positive affect and negative affect. In addition, we observed that negative affectivity was associated

with the largest cortisol increase in the solitude context, indicating that students with high negative affectivity showed a heightened affective and neuroendocrine response to solitude. In this larger sample, positive affectivity and autotelic personality did not moderate the association between solitude and cortisol. Negative affectivity is associated with neuroticism and is a risk factor for the development of depression and heightened affective and physiological response to negative contexts. The heightened sensitivity to solitude can be a biological vulnerability marker for the development of psychopathology. In contrast, positive affectivity, autotelic personality and traits associated with these constructs are associated with heightened sensitivity to reward, diminished affective and cardiovascular response to stress and a faster recovery after negative situations.

Although positive affect and autotelic personality were associated with better affective experiences in this context, they are not necessarily associated with decreases in cortisol, whereas negative affectivity is associated with both affective and neuroendocrine responses to stress. Other studies have shown that positive affectivity is associated with lower negative reactivity and negative affectivity is associated with higher positive affect. Therefore, it might be the case that the autotelic personality does not have a role in the neuroendocrine response to solitude. According to Cacioppo and colleagues (2006), the affective and physiological responses to solitude have a role in the development and maintenance of social connections. Therefore, individuals that are more sensitive to these processes might experience heightened affective and physiological responses, while positive personal characteristics might not necessarily be associated with affective and physiological responses in the context of daily solitude. In a previous study with a subset of this sample we had found a significant association between positive affectivity and cortisol levels in solitude: individuals with high positive affectivity had similar levels of cortisol in solitude and in other social contexts, whereas individuals with low positive affectivity had higher cortisol levels in solitude, compared to other social contexts. In this larger sample we observed that low positive affectivity was only marginally associated with increased cortisol levels in solitude, compared to other social contexts. In both cases, it seems that it is the lower levels of positive affectivity that put the individual at risk for a greater neuroendocrine response in this context. We speculate that in the smaller subset, the lower variation in

positive affectivity (M = 6.8, sd = 1.3 vs. M = 6.8, sd = 1.5) decreased the association between positive affectivity and cortisol in solitude, which seems to only become significant at extreme levels.

In sum, it seems that solitude is a negative context only if individuals are not able to bring order into consciousness and engage their attention in activities from which they may derive enjoyment and strength. However, stable characteristics seem to be associated with differences in the affective experience of solitude. Autotelic personality, high positive affectivity and low negative affectivity can protect individuals by increasing their responsiveness to positive situations, reducing sensitivity to stress and increasing emotional regulation and knowledge about themselves. However, low positive affectivity and high negative affectivity seem to heighten affective and neuroendocrine responses to solitude. The assessment of pre-morbid functioning, such as sensitivity to solitude, might offer advantages in the identification of students that might be at potential risk of developing depression.

The adaptation to college is often accompanied by feelings of loneliness and poor social adjustment. Although most feelings are transient and expected from the adaptation process, continuous feelings of loneliness and poor social adjustment are known to contribute to college dropout, depression, and suicidal ideation in college students (Furr, Westefeld, McConnell, & Jenkins, 2001; Gerdes & Mallinckrodt, 1994; Larose, Guay, & Boivin, 2002). Therefore, interventions should address not only affective states and cognitions, but also the development of interpersonal skills that can help students develop a supportive social network and experience solitude in more positive ways (Larson & Lee, 1996; Long & Averill, 2003; Long, Seburn, Averill, & More, 2003). Intervention studies could help clarify whether the development of a more positive experience of solitude can, over time, normalize cortisol response to this daily context, and whether peer programs aimed at easing the adaptation to college have positive effects in easing the affective and neuroendocrine response to solitude.

Engagement and personality in the context of study

In line with previous findings, study activities were associated with decreased positive affect and motivation even if optimal conditions to experience flow - challenges that match students' skills - were available. Negative experiences of study are often permeated by personal and cultural meanings and can create lack of interest, disengagement and even dropout. On the contrary, positive experiences in productive activities increase performance, satisfaction and enjoyment and have pervasive effects on the quality of subjective experience in other daily activities. In our findings, students that experienced high levels of engagement perceived study activities as effortless and enjoyable, and stopped worrying about themselves and what other may think. However, there were significant personal differences in the experience of study activities.

Personal characteristics were associated with differences in subjective experience in study activities, compared to other activities. Autotelic students with low negative affectivity showed similar levels of motivation in study and non-study activities, whereas less autotelic students with higher negative affectivity showed marked decreases in motivation levels in study activities. Although study activities are usually more challenging and balanced than other daily activities, previous research showed that less autotelic individuals tend to experience greater anxiety and stress in challenging tasks. Other characteristics associated with low levels of autotelic personality (e.g., low absorption, neuroticism and motives of "*fear of failure*") are associated with avoidance of tasks that might lead to failure and threaten the sense of self. Therefore, less autotelic students might abandon or invest less of their time and effort in study activities as a way to avoid stressful situations and protect their sense of self.

Although autotelic and less autotelic women perceived study activities as more challenging and balanced than other activities in daily life, autotelic women tended to rate them higher than less autotelic students. Autotelic students are known for the proactive search of opportunities of action and expression. They are able to find challenges and opportunities for action in activities that their less autotelic peers are not. They seem to be able to identify positive meanings on daily situations and might

also be better at avoiding demands that are too high, by selectively choosing which tasks to undertake and engaging in short-term adjustments to improve their subjective experience and achieve their main goal (McGuire & Botvinick, 2011). However, less autotelic individuals not only seem to perceive opportunities in the environment as less positive, but they also seem to lack the ability to identify challenges in the activities they participate in.

Differences in the experience of study activities reflect developmental processes and paths associated with the development and support of individual interests and resources. Although our participants came from a traditional college system, we observed significant personal differences in the experience of study, although there didn't seem to be significant differences in the amount of time spent studying. The population investigated might present specific characteristics that make them approach study activities more positively than other populations. College students are expected to have elaborated their *life theme* (Csikszentmihalyi & Beattie, 1979) around the field they are currently studying and have greater *perceived continuity* (Adlai-Gail, 1994) between current activities and future goals. However, they are still exploring possible professional and personal trajectories. The case of Montessori schools shows how the availability of challenges with support and autonomy increases the sense of self-determination, engagement and enjoyment in study activities. This has profound implications for the way students will continue to invest in the field of study and whether they continue to pursue scholarly activities. For example, Nakamura (2011) observed that the experiences in graduate school had profound implications for the determination of future academic career and personal and professional attitudes toward teaching, mentoring and investigation. Therefore, programs aimed at college students should identify individuals who have difficulties in identifying challenges and opportunities for action and expression in daily activities.

Intervention programs should include development of problem solving skills, in particular, by helping individuals identify smaller steps needed to gradually achieve a greater learning goal. This can increase the sense of mastery and self-efficacy, and increase motivation to be involved in study activities. Furthermore, working with students on the identification of positive personal meanings and perceived continuity of present activities into the future can increase feelings of self-determination,

motivation, performance and decrease dropout. Programs should also address the development of insight about one's emotions and thoughts, and about bodily reactions and circadian patterns. The knowledge about the circadian pattern can enable students to structure, whenever possible, their activities so that they have the greatest amount of physical and mental resources available. In addition, it might provide clues about what to do in idle moments and when to use those times to replenish one's resources.

Limitations and implications of findings.

We have outlined some limitations through the discussion of our findings. However, we believe that there are some limitations that deserve further attention because of their implications for future studies about the psychophysiology of the flow state and the autotelic personality. First, the sample was restricted to college women, therefore results cannot be generalized to men or to other age or socioeconomic groups. As mentioned earlier, cortisol responses seem to be associated with gender. Therefore, future studies should include male students to clarify whether engagement and cortisol in daily life show different associations according to gender.

Second, the moderate sample size restricted opportunities to examine individual differences more accurately. However, the procedure entailed 6 days of repeated ESM reports and saliva sampling, which allowed for reliable detection of within-person associations among daily contexts, momentary subjective experience, and cortisol. In the current research, we did not find significant differences between momentary subjective experience and cortisol levels between students in the first year, or other years, and students living with or away from their parents. Previous studies have shown that the first college year is often associated with transient feelings of loneliness and depression however, we did not find significant differences in the subjective experience of women in the first year, compared to women in other years. However, a greater sample size would allows us to investigate whether less autotelic students are more sensitive to stressful contexts than autotelic students during the course of their college life and if they are closer, or farther from their family network.

Third, it is important to note that trait affectivity and autotelic personality were operationalized as the mean of the individual's momentary scores reported over the sampling week, in contrast to more global retrospective measures. The advantage of a measure based on aggregated real-time assessments is that this estimate is relatively free from the interference of cognitive biases and social desirability that can reduce the reliability of retrospective measures. The personality composites derived from the ESM reports in the current research effectively differentiated momentary subjective experiences in different daily contexts, neuroendocrine responses to solitude and overall neuroendocrine function. This further supports the utility of incorporating aggregated daily measures of affect as predictors of between-individual differences in physiological outcomes (Steptoe, Dockray, & Wardle, 2009). However, we believe that the addition of global measures of loneliness, depression, resilience, extraversion and related personality traits could help clarify the nature of the observed findings. In particular, global measures of personality would help clarify the associations between affectivity, autotelic personality, daily contexts and neuroendocrine function.

The ESM presents some limitations that may have important implications for current findings. The ESM is a demanding methodology and, as such, participants included in the final sample have particular characteristics that make them willing, interested and motivated to participate.

Due to the nature of flow in daily life, we suggest that very intense experiences of engagement can be misrepresented in ESM studies. Participants may not fill in the ESF in situations of high engagement because they cannot hear the signal (e.g., training sports), they delay the report for more than 20 minutes, or they purposefully leave the electronic beeper elsewhere (e.g., going to church, swimming pool). Therefore, engagement in sports and other activities of interest might be easily misrepresented using a random-signal contingent design. Therefore, we suggest that future research interested in the study of flow and physiology in daily life should ally signal- and event-contingent sampling to assess hobbies and activities that students participate in.

Finally, the ESM provides a vast amount of information about the everyday life of participants. This information is at times overwhelming when it comes to the amount of information gathered, but also when in comes to choosing which information to

analyze. As a result, the current research project has estimated several models and the risk of type I error is present. To reduce the probability of chance findings, we used scales instead of individual items whenever possible.

Conclusions

In conclusion, we believe our findings contribute to increase the knowledge about the flow state, the autotelic personality and their neuroendocrine correlates in the everyday life of female college students. The finding that the balance between challenges and skills is associated with better quality of experience, but that it does not always predict an autotelic experience of intense engagement extends the findings previously discussed by others (e.g., Engeser & Rheinberg, 2008; Moneta & Csikszentmihlayi, 1988; Schmidt, et al., 2007). We confirmed that the interaction between the availability of internal resources and external opportunities could be an adequate measure to asses the flow state, especially in studies investigating the physiological correlates of flow.

We proposed a new measure to assess the autotelic personality based on the internal components of experience instead of the frequency of flow states reported during the assessment week. A global measure might reflect not only the experience of flow, but the overall tendency for autotelic students to exhibit greater attentional resources, intrinsic motivation and positive affectivity, even if the environment doesn't offer high balanced experiences during the assessment week. Current findings confirmed that the measure of autotelic personality used in this research project was significantly associated with better psycho/affective experiences and overall lower fatigue in daily contexts, which goes in line with previous assumptions about the autotelic personality trait (e.g., Nakamura & Csikszentmihalyi, 2002). However, further investigation is needed to understand how this personality measure is associated with other retrospective measures (e.g., extraversion, neuroticism, openness to experience, resilience and absorption).

We observed that experiencing engagement was associated with better affective, cognitive and motivational experience in solitude and in study activities, regardless of individual characteristics. In particular, female students with high negative affectivity showed a heightened affective and neuroendocrine response to solitude and may be in particular risk in this context. The associations between negative affectivity and depression emphasize the need to restructure cognitions and develop interpersonal skills with college students. The ability to develop solid social networks from which to derive strong social support can have a buffering effect on the response to solitude, allowing individuals to experience high engagement and lower affective and neuroendocrine responses in this context. Hence, our study confirms that the affective and neuroendocrine response to solitude can be a biological vulnerability marker. Longitudinal studies would allow us to observe whether the response to solitude is a positive indicator of pre-morbid function, and whether interventions can ameliorate the affective and neuroendocrine responses to this context.

Positive experiences in study activities are associated with greater enjoyment and investment of effort and time in these activities. The implications of negative experiences in study can lead to the development of depression and even dropout as students find themselves unable to respond to college life demands. Less autotelic students seemed to be in particular risk in this context and would benefit the most from preventive programs aimed at helping individuals develop psychological and social resources. Intervention programs for college students should help identify positive personal meanings in study activities and interpret tasks as challenges and opportunities to learn and grow instead of threats.

In the study of the psychophysiology of flow and autotelic personality, we found that many questions remain to be answered. We did not find significant associations between engagement and cortisol. However, we had an all-female sample, which did not allow us to observe possible gender differences in the association between cortisol and engagement. Also, we believe that research on the psychophysiology of flow in daily life would benefit from the inclusion of event-contingent sampling. Event-contingent allows the assessment of activities that might be missed otherwise, and offers a clearer picture of the associations between engagement and cortisol in activities with different characteristics (e.g., physical activation vs. mental activation).

In addition, the measurement of pre- and post-task physiological markers could prove important in the study of the flow state and the autotelic personality. A fast recovery from stressful situations is thought to be an indicator of healthy psychological and physiological function (Dienstbier, 1989; Dienstbier & Zillig, 2005; Hawkley, et al., 2005; Tugade & Fredrickson, 2004; Tugade, et al., 2004), in particular because too high and too low levels of cardiovascular, neuroendocrine and immune markers are known to have deleterious effects on psychological and physical health.

Also, previous studies have suggested that physiological measures of sympathetic activation might be strongly associated with states of intense engagement and activation without distress (Frankenhauser & Lundberg, 1982; Keller et al., 2011; Lundberg & Frankenhauser, 1980). Therefore, we suggest that the inclusion of other physiological measures in the study of the psychophysiology of the flow state could clarify the associations between this state and physiological function that might promote and help sustain it. For example, salivary alpha-amylase, a marker of sympathetic nervous system activity, is associated with psychological stress reactivity and mood, and is relatively independent of the cortisol response (Nater, et al., 2006; Nater, et al., 2005; Nater, Rohleder, Schlotz, Ehlert, & Kirschbaum, 2007). Until recently, the assessment of such markers was costly and difficult, especially in ambulatory studies, such as experience sampling protocols. However, recent advancements have made it possible to assess salivary alpha-amylase in ambulatory studies more easily and less expensively (e.g., Robles, et al., 2011).

This project, like many others before and many after, leads to the emergence of new research questions that we hope will be investigated in the future. Certainly, finalizing a dissertation is not the end of a project, but hopefully, an indication of the starting point of a broader investigation.

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Appendices

Appendix A
Experience sampling materials – examples.

Appendix B
Informed consent.

Appendix C
Preliminary models: estimates of confounding effects of time on momentary subjective experience and cortisol.

Appendix D
Post hoc estimations of interaction effects.

Appendix A
Experience sampling method materials - examples

1. Experience sampling form.

Each ESF notepad contained 40 reports. Also, each notepad contained an initial page with instructions reminding how to fill the report and the contact information of the researcher. For this particular study, an extra page was included in which participants registered the waking hour, time of meals, medication and alcohol intake each day.

At the start of each report, participants registered the date, time of the beep according to the pager, and time of filling the report.

At the end of each report, participants were asked to answer whether this was a new day, and to report whether something important had happened since the last report.

Open questions and *ratings* included in the Experience Sampling Form (example):

- **Em que é que estava a pensar?**
- **Onde estava?**
- **Qual era a coisa principal que estava a fazer? Que outra coisa estava a fazer?**
- *Estava bem concentrado?*
- *Era difícil concentrar-se?*
- *Estava a reflectir sobre si?*
- *Sentiu que tinha o controlo da situação?*
- Descreva como se sentia no momento da chamada:
    - *bem-desperto, feliz, apático, sozinho…*
- *A actividade que estava a realizar era desafiante e representava uma oportunidade para ser exprimir e agir?*
- *Considerando as suas capacidades e competencias pessoais, estava a conseguir fazer frente à situação?*
- *Pretendia fazer outra coisa(likert)*? **Que coisa?**

- *Havia qualquer coisa de importante na actividade que estava a realizar (likert)?*

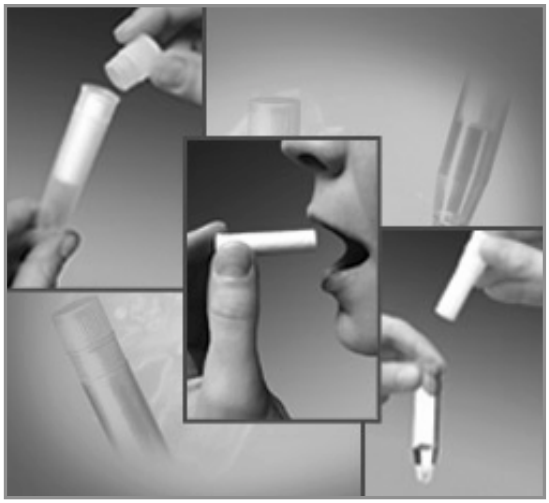
Que coisa?

- **Com quem estava?**
    - *Queria estar com outra pessoa (likert)?* **Com quem?**
- *Teve alguma sensação física em especial (Likert)?* **Qual?**
- *O tempo estava a passar:* (0 – lento; 12 – rápido)
- *Sentia-*se *satisfeito consigo próprio?*
- *Queria estar noutro lugar (likert)?* **Onde?**
- *A actividade que estava a realizar era importante para algum dos seus objectivos gerais de vida (likert)?* **Qual ou quais?**

2. Psycho-beeper.

By: Machado, Gomes, and Freire (2009)

3. Salivettes®



Appendix B
Informed consent

Projecto: "Psicofisiologia no Quotidiano" – III Fase Out-Dez 2009-10-18

Consentimento Informado

Eu, _____ aceito participar no estudo a decorrer no âmbito do Doutoramento em Psicologia Social, na Universidade do Minho, dirigido pela Drª Gabriela Matias e orientado pela Doutora Teresa Freire, cujo tema incide sobre a qualidade da experiência no dia a dia: processos individuais e psicológicos.

Declaro que tomei conhecimento:

- acerca dos termos de confidencialidade e anonimato, sob os quais os meus dados serão tratados;
- acerca dos métodos e técnicas a utilizar durante a investigação;

Comprometo-me a:

- utilizar o material em boas condições e apenas o utilizar no âmbito da investigação:
  - Psych-beeper nr: ____
  - Esfignomanómetro nr: ____
- procurar ser o mais rigoroso possível na metodologia durante o período do estudo.

Assinatura: _____

Em caso de dúvida, problema ou avaria, por favor contactar:
Drª Gabriela Matias
Tel: 00351 917 000 218
Email: gabrielapmatias@gmail.com

Appendix C

Multilevel Estimates for Effects of Time on Outcome Measures

CORTISOL (LOG-CORTISOL).

Table I
Multilevel estimates of effects of time on cortisol levels.

	B (SE)			
	M1	M2	M3	M4
Time	-.14 (.00)***	-.15 (.00)***	-.13 (.01)***	-.13 (.01)***
$Time^2$		.01 (.00)***	.01 (.00)***	.01 (.00)***
$Time^3$			-.00 (.00)†	-.00 (.00)
$Time^4$				-.00 (.00)†
Intercept	1.51 (.04)***	1.40 (.01)***	1.39 (.05)***	1.37 (.05)***

Notes. Outcome is log-cortisol.
B – unstandardized regression coefficient; SE – standard error.
$^{\dagger}p < .10$ $^{*}p < .05$ $^{**}p < .01$ $^{***}p < .001$

- Introduction of *random-effect of time* improved the model significantly. (LR $\chi^2 = 15.11, p < .001$).

- *M2*: Including $Time^2$ improved the model significantly. (LR $\chi^2 = 35.48, p < .001$).

- *M3*: Including $Time^3$ improved the model significantly. (LR $\chi^2 = 17.32, p < .001$)

- *M4*: Including $Time^4$ improved the model significantly. (LR $\chi^2 = 3.81, p < .05$).

POSITIVE AFFECT (PA)

Table II

Multilevel estimates of effects of time on momentary positive affect.

	B (SE)	
	M1	M2
Time	.03 (.01)**	.04 (.01)***
Time2		-.01 (.00)***
Intercept	6.82 (.18)***	6.98 (.18)***

Notes. Outcome is positive affect.
B – unstandardized regression coefficient; SE – standard error.
$^{\dagger}p < .10$ $^{*}p < .05$ $^{**}p < .01$ $^{***}p < .001$

• Introduction of *random-effect of time* improved the model significantly. (LR $\chi^2 = 24.67, p < .001$).

• *M2*: Including Time^2 improved the model significantly. (LR $\chi^2 = 23.52, p < .001$).

NEGATIVE AFFECT (NA)

Table III

Multilevel estimates of effects of time on momentary negative affect.

	B (SE)	
	M1	M2
Time	-.02 (.01)*	-.02 (.01)**
Time2		.05 (.00)**
Intercept	2.70 (.23)***	2.62 (.23)***

Notes. Outcome is negative affect.
B – unstandardized regression coefficient; SE – standard error.
$^{\dagger}p < .10$ $^{*}p < .05$ $^{**}p < .01$ $^{***}p < .001$

• Introduction of *random-effect of time* improved the model marginally. (LR $\chi^2 = 3.35, p = .07$).

• *M2*: Including Time^2 improved the model significantly. (LR $\chi^2 = 8.56, p < .01$).

EFFORTLESS ATTENTION

Table IV

Multilevel estimates of effects of time on momentary effortless attention.

	B (SE)	
	M1	M2
Time	.05 (.01)***	.05 (.01)***
Time2		-.01 (.00)***
Intercept	7.62 (.18)***	7.81 (.18)***

Notes. Outcome is effortless attention.
B – unstandardized regression coefficient; SE – standard error.
$^{\dagger}p<.10$ $^{*}p<.05$ $^{**}p<.01$ $^{***}p<.001$

- Introduction of *random-effect of time* did not improve the model significantly.
(LR $\chi^2 = .14, p = .71$)

- *M2*: Including Time^2 improved the model significantly.
(LR $\chi^2 = 23.52, p < .001$).

MOTIVATION

Table V

Multilevel estimates of effects of time on momentary motivation.

	B (SE)	
	M1	M2
Time	.06 (.03)*	.05 (.03)†
Time2		.01 (.01)**
Intercept	8.28 (.24)***	8.07 (.25)***

Notes. Outcome is motivation.
B – unstandardized regression coefficient; SE – standard error.
$^{\dagger}p<.10$ $^{*}p<.05$ $^{**}p<.01$ $^{***}p<.001$

- Introduction of *random-effect of time* improved the model significantly.
(LR $\chi^2 = 3.88, p < .05$)

- *M2*: Including Time^2 improved the model significantly.
(LR $\chi^2 = 6.05, p < .05$)

FATIGUE.

Table VI

Multilevel estimates of effects of time on momentary fatigue.

	B (SE)	
	M1	M2
Time	-.05 (.02)*	-.08 (.02)***
Time2		.04 (.00)***
Intercept	4.37 (.26)***	3.78 (.26)***

Notes. Outcome is fatigue.
B – unstandardized regression coefficient; SE – standard error.
$^{\dagger}p<.10$ $^{*}p<.05$ $^{**}p<.01$ $^{***}p<.001$

- Introduction of *random-effect of time* improved the model significantly. (LR $\chi^2 = 62.86, p < .001$)

- *M2*: Including Time^2 improved the model significantly. (LR $\chi^2 = 171.98, p < .001$).

SELF-CONSCIOUSNESS

Table VII

Multilevel estimates of effects of time on momentary self-consciousness.

	B (SE)	
	M1	M2
Time	.04 (.02)*	.04 (.02)*
Time2		-.00 (.00)
Intercept	3.98 (.24)***	4.05 (.24)***

Notes. Outcome is self-consciousness.
B – unstandardized regression coefficient; SE – standard error.
$^{\dagger}p<.10$ $^{*}p<.05$ $^{**}p<.01$ $^{***}p<.001$

- Introduction of *random-effect of time* improved the model significantly. (LR $\chi^2 = 4.00, p < .05$)

- *M2*: Including Time^2 did not improve the model significantly. (LR $\chi^2 = 1.10, p = .29$)

CREATIVITY

Table VIII

Multilevel estimates of effects of time on momentary creativity.

	B (SE)	
	M1	M2
Time	.02 (.01)	.02 (.01)†
Time2		-.01 (.00)***
Intercept	4.23 (.24)***	4.40 (.24)***

Notes. Outcome is creativity.
B – unstandardized regression coefficient; SE – standard error.
$^{\dagger}p<.10$ $^{*}p<.05$ $^{**}p<.01$ $^{***}p<.001$

- Introduction of *random-effect of time* improved the model significantly. (LR $\chi^2 = 4.42, p < .05$)

- *M2*: Including Time^2 improved the model significantly. (LR $\chi^2 = 13.66, p < .001$)

PERCEIVED IMPORTANCE OF THE ACTIVITY

Table IX

Multilevel estimates of effects of time on momentary importance of the activity.

	B (SE)	
	M1	M2
Time	-.06 (.02)**	-.06 (.02)**
Time2		-.00 (.00)
Intercept	4.45 (.24)***	4.47 (.25)***

Notes. Outcome is perceived importance of activity.
B – unstandardized regression coefficient; SE – standard error.
$^{\dagger}p<.10$ $^{*}p<.05$ $^{**}p<.01$ $^{***}p<.001$

- Introduction of *random-effect of time* improved the model marginally. (LR $\chi^2 = 3.56, p = .06$)

- *M2*: Including Time^2 did not improve the model. (LR $\chi^2 = .10, p = .76$)

CONTROL

Table X

Multilevel estimates of effects of time on momentary control.

	B (SE)	
	M1	M2
Time	-.01 (.02)	-.01 (.01)
Time2		-.01 (.00)*
Intercept	6.58 (.27)***	6.68 (.27)***

Notes. Outcome is control.
B – unstandardized regression coefficient; SE – standard error.
$^{\dagger}p<.10$ $^{*}p<.05$ $^{**}p<.01$ $^{***}p<.001$

- Introduction of *random-effect of time* improved the model significantly. (LR $\chi^2 = 12.80, p < .001$)

- *M2*: Including Time^2 improved the model significantly. (LR $\chi^2 = 3.96, p < .05$)

CHALLENGES

Table XI

Multilevel estimates of effects of time on momentary challenges.

	B (SE)	
	M1	M2
Time	.01 (.02)	.02 (.02)
Time2		-.02 (.00)***
Intercept	3.68 (.22)***	3.92 (.23)***

Notes. Outcome is challenges.
B – unstandardized regression coefficient; SE – standard error.
$^{\dagger}p<.10$ $^{*}p<.05$ $^{**}p<.01$ $^{***}p<.001$

- Introduction of *random-effect of time* improved the model marginally. (LR $\chi^2 = 3.54, p = .06$)

- *M2*: Including Time^2 improved the model significantly. (LR $\chi^2 = 13.58, p < .001$)

SKILLS

Table XII

Multilevel estimates of effects of time on momentary skills.

	B (SE)	
	M1	M2
Time	.03 (.01)*	.03 (.01)*
Time2		-.01 (.00)*
Intercept	8.04 (.25)***	8.15 (.24)***

Notes. Outcome is skills.
B – unstandardized regression coefficient; SE – standard error.
$^{\dagger}p<.10$ $^{*}p<.05$ $^{**}p<.01$ $^{***}p<.001$

- Introduction of *random-effect of time* did not improve the model.

(LR $\chi^2 = 1.94, p = .16$)

- *M2*: Including Time^2 improved the model significantly.

(LR $\chi^2 = 5.39, p < .05$)

BALANCE LEVELS (BL)

Table XIII

Multilevel estimates of effects of time on momentary balance levels.

	B (SE)	
	M1	M2
Time	.01 (.02)	.02 (.02)
Time2		-.01 (.00)***
Intercept	4.11 (.23)***	4.32 (.24)***

Notes. Outcome is balance levels.
B – unstandardized regression coefficient; SE – standard error.
$^{\dagger}p<.10$ $^{*}p<.05$ $^{**}p<.01$ $^{***}p<.001$

- Introduction of *random-effect of time* did not improve the model.

(LR $\chi^2 = 2.24, p = .13$)

- *M2*: Including Time^2 improved the model significantly.

(LR $\chi^2 = 10.06, p < .01$)

Table XIV

Multilevel estimates of effects of time on momentary engagement levels.

	B (SE)	
	M1	M2
Time	.03 (.02)	.03 (.02)
Time2		-.01 (.00)*
Intercept	4.09 (.24)***	4.24 (.25)***

Notes. Outcome is engagement levels.
B – unstandardized regression coefficient; SE – standard error.
$^{\dagger}p<.10$ $^{*}p<.05$ $^{**}p<.01$ $^{***}p<.001$

- Introduction of *random-effect of time* did not improve the model. (LR $\chi^2 = 1.49, p = .22$)

- *M2*: Including Time^2 improved the model significantly. (LR $\chi^2 = 4.35, p < .05$)

Appendix D

Post hoc estimations of interaction effects

The effects of the interactions between predictor (study, solitude) and moderator (engagement levels, personality variables) on outcome measures (subjective experience, cortisol) were estimated using linear combination analysis (STATA command: LINCOM).

We used linear combination to estimate interaction effects on outcome measures at different levels of intensity of the moderator. With this method we were able to estimate interaction effects of the moderator at average levels and one standard deviation above and below.

Engagement levels were centered around the individual mean. The value [0] reflects each individual's average in this measure. Positive affectivity, negative affectivity and autotelic personality were centered around the grand-mean. The value [0] represents the sample's average for each personal measure.

Moderating effects of engagement levels on the subjective experience of solitude.

Table 1 –Post hoc estimations of the effect of the interaction between engagement and solitude on balance levels.

	B	SE
High (+1sd)	-.10	.11
Average (0)	-.22**	.08
Low (-1sd)	-.43***	.11

Notes. Outcome is balance levels.
sd - standard deviation; *B* – unstandardized coefficient; SE – standard error.
†$p < .10$. *$p < .05$. **$p < .01$. ***$p < .001$.

Table 2 - Post hoc estimations of the effect of the interaction between engagement and solitude on motivation.

	B	SE
High (+1sd)	-.24	.28
Average (0)	.06	.19
Low (-1sd)	.58*	.27

Notes. Outcome is motivation.
sd - standard deviation; *B* – unstandardized coefficient; SE – standard error.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table 3 - Post hoc estimations of the effect of the interaction between engagement and solitude on fatigue.

	B	SE
High (+1sd)	.14	.15
Average (0)	.36***	.10
Low (-1sd)	.76***	.14

Notes. Outcome is fatigue.
sd - standard deviation; *B* – unstandardized coefficient; SE – standard error.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table 4 - Post hoc estimations of the effect of the interaction between engagement and solitude on creativity.

	B	SE
High (+1sd)	.16	.14
Average (0)	-.04	.10
Low (-1sd)	-.40**	.13

Notes. Outcome is creativity.
sd - standard deviation; *B* – unstandardized coefficient; SE – standard error.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Moderating effects of engagement levels on the subjective experience of study activities.

Table 5 - Post hoc estimations of the effect of the interaction between engagement and study on balance levels.

	B	SE
High (+1sd)	.64***	.11
Average (0)	1.34***	.08
Low (-1sd)	1.98***	.13

Notes. Outcome is balance levels.
sd - standard deviation; *B* – unstandardized coefficient; SE – standard error.
†$p < .10$. *$p < .05$. **$p < .01$. ***$p < .001$.

Table 6 - Post hoc estimations of the effect of the interaction between engagement and study on effortless attention.

	B	SE
High (+1sd)	.25	.17
Average (0)	-.32**	.12
Low (-1sd)	-1.32***	.21

Notes. Outcome is effortless attention.
sd - standard deviation; *B* – unstandardized coefficient; SE – standard error.
†$p < .10$. *$p < .05$. **$p < .01$. ***$p < .001$.

Table 7 - Post hoc estimations of the effect of the interaction between engagement and study on motivation.

	B	SE
High (+1sd)	2.16***	.27
Average (0)	-3.04***	.19
Low (-1sd)	-4.54***	.33

Notes. Outcome is motivation.
sd - standard deviation; *B* – unstandardized coefficient; SE – standard error.
†$p < .10$. *$p < .05$. **$p < .01$. ***$p < .001$.

Table 8 - Post hoc estimations of the effect of the interaction between engagement and study on self-consciousness.

	B	SE
High (+1sd)	-1.57***	.22
Average (0)	-1.25***	.15
Low (-1sd)	-.69**	.27

Notes. Outcome is self-consciousness.
sd - standard deviation; *B* – unstandardized coefficient; SE – standard error.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table 9 - Post hoc estimations of the effect of the interaction between engagement and study on challenges.

	B	SE
High (+1sd)	1.04***	.13
Average (0)	1.43***	.09
Low (-1sd)	2.11***	.16

Notes. Outcome is challenges.
sd - standard deviation; *B* – unstandardized coefficient; SE – standard error.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Moderating effects of autotelic personality on the subjective experience of solitude.

Table 10 - Post hoc estimations of the effect of the interaction between autotelic personality and solitude on negative affect.

	B	SE
High (+1sd)	-.15	.39
Average (0)	.49***	.08
Low (-1sd)	1.33***	.39

Notes. Outcome is negative affect.
sd - standard deviation; *B* – unstandardized coefficient; SE – standard error.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table 11 - Post hoc estimations of the effect of the interaction between autotelic personality and solitude on importance of activity.

	B	SE
High (+1sd)	-3.55***	1.04
Average (0)	-.83***	.21
Low (-1sd)	2.72**	1.04

Notes. Outcome is importance of activity.
sd - standard deviation; *B* – unstandardized coefficient; SE – standard error.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Moderating effects of positive affectivity on the subjective experience of solitude.

Table 12 - Post hoc estimations of the effect of the interaction between positive affectivity and solitude on negative affect.

	B	SE
High (+1sd)	-.14	.27
Average (0)	.48***	.07
Low (-1sd)	1.32***	.27

Notes. Outcome is negative affect.
sd - standard deviation; *B* – unstandardized coefficient; SE – standard error.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table 13 - Post hoc estimations of the effect of the interaction between positive affectivity and solitude on challenges.

	B	SE
High (+1sd)	-2.21***	.65
Average (0)	-1.23***	.17
Low (-1sd)	.10	.65

Notes. Outcome is challenges.
sd - standard deviation; *B* – unstandardized coefficient; SE – standard error.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table 14 - Post hoc estimations of the effect of the interaction between negative affectivity and solitude on negative affect.

	B	SE
High (+1sd)	.84***	.10
Average (0)	.68***	.06
Low (-1sd)	.32***	.10

Notes. Outcome is negative affect.
sd - standard deviation; *B* – unstandardized coefficient; SE – standard error.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table 15 - Post hoc estimations of the effect of the interaction between negative affectivity and solitude on importance of activity.

	B	SE
High (+1sd)	.10	.27
Average (0)	-.21	.18
Low (-1sd)	-.91***	.27

Notes. Outcome is importance of activity.
sd - standard deviation; *B* – unstandardized coefficient; SE – standard error.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table 16 - Post hoc estimations of the effect of the interaction between negative affectivity and solitude on Challenges.

	B	SE
High (+1sd)	-.39	.25
Average (0)	-.81***	.16
Low (-1sd)	-1.70***	.24

Notes. Outcome is challenges.
sd - standard deviation; *B* – unstandardized coefficient; SE – standard error.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Moderating effects of autotelic personality on the subjective experience of study activities.

Table 17 - Post hoc estimations of the effect of the interaction between autotelic personality and study on motivation.

	B	SE
High (+1sd)	-.04	1.31
Average (0)	-2.31***	.27
Low (-1sd)	-5.28***	1.28

Notes. Outcome is motivation.
sd - standard deviation; *B* – unstandardized coefficient; SE – standard error.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table 18 - Post hoc estimations of the effect of the interaction between autotelic personality and study on challenges.

	B	SE
High (+1sd)	4.43***	1.00
Average (0)	2.62***	.20
Low (-1sd)	.25	.98

Notes. Outcome is challenges.
sd - standard deviation; *B* – unstandardized coefficient; SE – standard error.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table 19 - Post hoc estimations of the effect of the interaction between autotelic personality and study on balance levels.

	B	SE
High (+1sd)	4.15***	1.05
Average (0)	2.46***	.21
Low (-1sd)	.26	1.03

Notes. Outcome is balance levels.
sd - standard deviation; *B* – unstandardized coefficient; SE – standard error.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table 20 - Post hoc estimations of the effect of the interaction between autotelic personality and study on engagement levels.

	B	SE
High (+1sd)	4.83***	1.14
Average (0)	1.74***	.24
Low (-1sd)	-2.31*	1.12

Notes. Outcome is engagement levels.
sd - standard deviation; *B* – unstandardized coefficient; SE – standard error.

†$p < .10$. *$p < .05$. **$p < .01$. ***$p < .001$.

Moderating effects of positive affectivity on the subjective experience of study activities.

Table 21 - Post hoc estimations of the effect of the interaction between positive affectivity and study on self-consciousness.

	B	SE
High (+1sd)	-.00	.69
Average (0)	-.98***	.18
Low (-1sd)	-2.28***	.68

Notes. Outcome is self-consciousness.
sd - standard deviation; *B* – unstandardized coefficient; SE – standard error.
†$p < .10$. *$p < .05$. **$p < .01$. ***$p < .001$.

Table 22 - Post hoc estimations of the effect of the interaction between positive affectivity and study on importance of activity.

	B	SE
High (+1sd)	5.93***	.71
Average (0)	3.96***	.19
Low (-1sd)	1.32†	.70

Notes. Outcome is importance of activity.
sd - standard deviation; *B* – unstandardized coefficient; SE – standard error.
†$p < .10$. *$p < .05$. **$p < .01$. ***$p < .001$.

Table 23 - Post hoc estimations of the effect of the interaction between positive affectivity and study on challenges.

	B	SE
High (+1sd)	3.52***	.70
Average (0)	2.51***	.18
Low (-1sd)	1.16†	.68

Notes. Outcome is challenges.
sd - standard deviation; *B* – unstandardized coefficient; SE – standard error.
†$p < .10$. *$p < .05$. **$p < .01$. ***$p < .001$.

Table 24 - Post hoc estimations of the effect of the interaction between positive affectivity and study on skills.

	B	SE
High (+1sd)	-1.68**	.55
Average (0)	-.69***	.14
Low (-1sd)	-.63	.54

Notes. Outcome is skills.
sd - standard deviation; *B* – unstandardized coefficient; SE – standard error.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table 25 - Post hoc estimations of the effect of the interaction between positive affectivity and study on creativity.

	B	SE
High (+1sd)	-.62	.47
Average (0)	.15	.12
Low (-1sd)	1.19**	.46

Notes. Outcome is creativity.
sd - standard deviation; *B* – unstandardized coefficient; SE – standard error.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Moderating effects of negative affectivity on the subjective experience of study activities.

Table 26 - Post hoc estimations of the effect of the interaction between negative affectivity and study on motivation.

	B	SE
High (+1sd)	-3.34***	.33
Average (0)	-2.90***	.22
Low (-1sd)	-1.97***	.36

Notes. Outcome is motivation.
sd - standard deviation; *B* – unstandardized coefficient; SE – standard error.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table 27 - Post hoc estimations of the effect of the interaction between negative affectivity and study on effortless attention.

	B	SE
High (+1sd)	-.93***	.21
Average (0)	-.33*	.14
Low (-1sd)	.97***	.22

Notes. Outcome is effortless attention.
sd - standard deviation; *B* – unstandardized coefficient; SE – standard error.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table 28 - Post hoc estimations of the effect of the interaction between negative affectivity and study on control.

	B	SE
High (+1sd)	-.75***	.19
Average (0)	-.50***	.13
Low (-1sd)	.02	.21

Notes. Outcome is control.
sd - standard deviation; *B* – unstandardized coefficient; SE – standard error.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table 29 - Post hoc estimations of the effect of the interaction between negative affectivity and study on challenges.

	B	SE
High (+1sd)	1.81***	.25
Average (0)	2.15***	.17
Low (-1sd)	2.89***	.27

Notes. Outcome is challenges.
sd - standard deviation; *B* – unstandardized coefficient; SE – standard error.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table 30 - Post hoc estimations of the effect of the interaction between negative affectivity and study on balance levels.

	B	SE
High (+1sd)	1.51***	.26
Average (0)	1.96***	.17
Low (-1sd)	2.93***	.28

Notes. Outcome is balance levels.
sd - standard deviation; *B* – unstandardized coefficient; SE – standard error.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table 31 - Post hoc estimations of the effect of the interaction between negative affectivity and study on engagement levels.

	B	SE
High (+1sd)	.12	.28
Average (0)	.87***	.19
Low (-1sd)	2.48***	.31

Notes. Outcome is engagement levels.
sd - standard deviation; *B* – unstandardized coefficient; SE – standard error.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Moderating effects of negative affectivity on cortisol levels in solitude.

Table 32 - Post hoc estimations of the effect of the interaction between negative affectivity and study on cortisol.

	B	SE
High (+1sd)	.23***	.06
Average (0)	.15***	.04
Low (-1sd)	-.02	.06

Notes. Outcome is log-cortisol.
sd - standard deviation; *B* – unstandardized coefficient; SE – standard error.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.